Duo-sol

Solvent Extraction

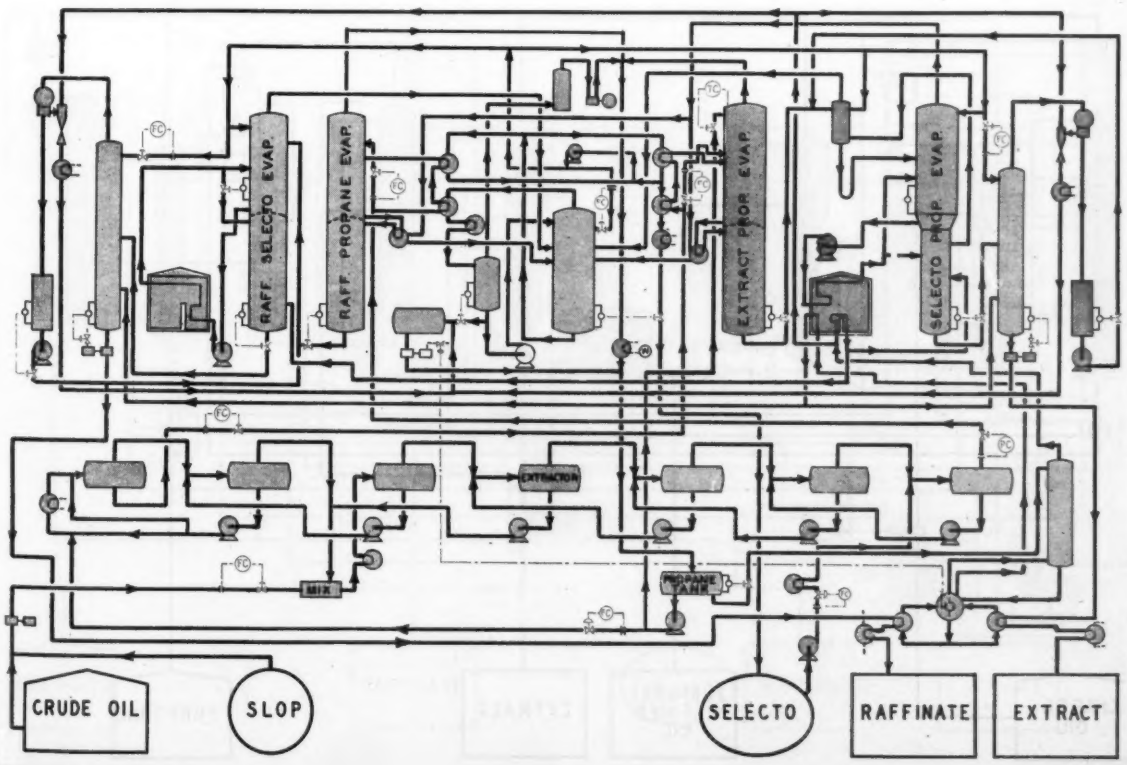
THE Duo-Sol process employs two solvents, liquid propane as solvent for the raffinate, while a liquid known as Selecto is the extract or reject solvent. These two solvents are essentially immiscible, and serve to make the two components, raffinate and extract, more easily and completely separable.

The liquid propane is pumped into one end of the extraction system, the Selecto solvent into the opposite end of the system. The raw charge stock enters at an intermediate point. The system includes a series of mixing and settling-separating zones in which the two countercurrent solvents and the charge are mixed and the two resulting solutions are separated in turn by settling. The propane solution differs widely from the extract solution and settling is relatively rapid by gravity. Operation is under sufficient pressure to maintain the propane phase in liquid form, and at a temperature of 90° to 150° F., through a seven-stage system.

Solvent recovery is carried out in separate equipment but in the same three general steps. Under relatively high pressure (about 250 psig.), the propane is evaporated from each solution, a large percentage being recovered from the raffinate phase and only a small amount from the extract phase. Under intermediate pressure (about 70 psig.), the relatively high-boiling Selecto is recovered. Each phase is then stripped of solvent under vacuum to recover the last traces of solvents and to strip the finished products entirely of solvents. Heat exchange between the higher-temperature Selecto extract fraction and the lower-boiling propane fraction is used to vaporize the propane.

All water and stripping steam in the process are maintained in a closed system. All Selecto vapors containing water vapor enter a dehydrating tower from which the dry solvent is removed as a bottoms stream, and from which an overhead stream (vapor), which contains about 10 per cent Selecto, a constant-boiling mixture, is taken. The water containing Selecto is charged to the propane surge tank, in which propane absorbs most of the other solvent. The water containing only a fraction of 1 per cent of Selecto is sent as reflux to a tower in the steam-generating system; overhead from this tower contains all the Selecto in the stripping steam feed. All condensate from vacuum jet condensers and from vacuum towers is returned to the water system.

This process is licensed by Max B. Miller & Co., New York.



Furfural

Solvent Extraction

THE treatment of oils with furfural is by countercurrent extraction in a treating tower packed with nests of raschig rings. Being nonacidic and nontoxic furfural can be handled safely and because of its physical properties, namely high specific gravity (1.16), low boiling point (323° F.), and low solid point (—38° F.), furfural is ideally suited to countercurrent extraction of oils.

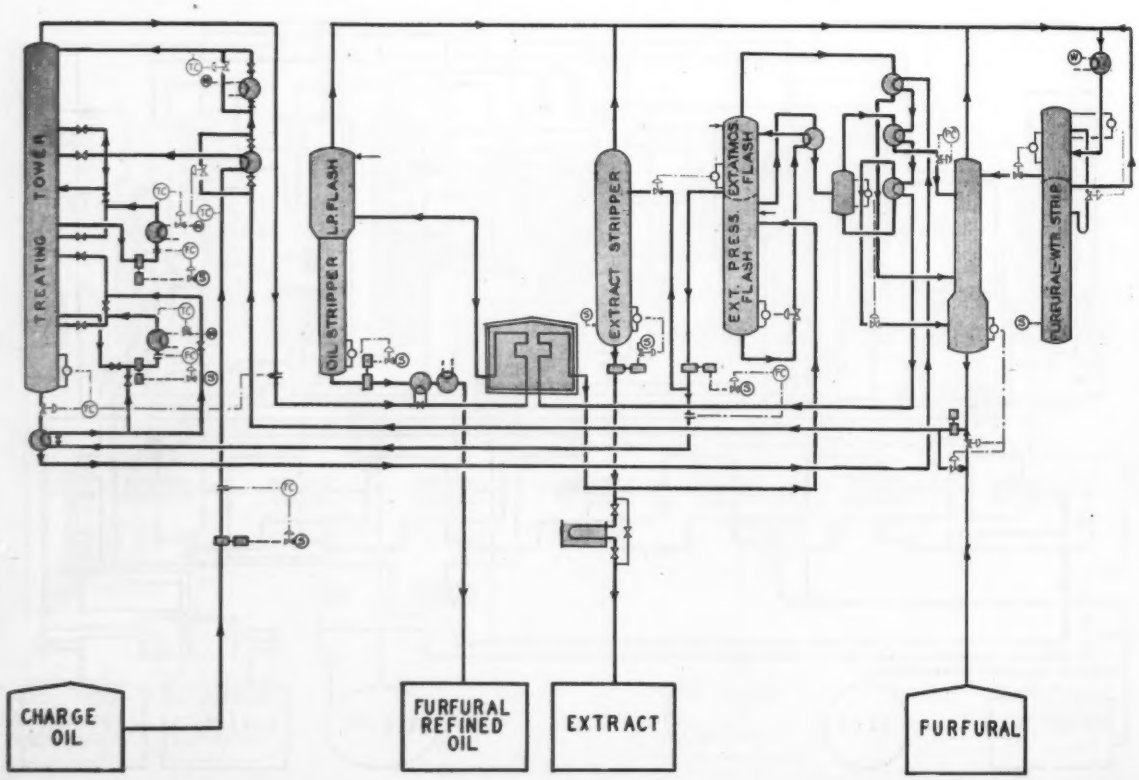
The equipment employed in the most recent plants comprises an improved and highly efficient treating tower; heaters, flash towers and strippers for the recovery of furfural from both the raffinate and extract mixtures; fractionators for the separation of furfural from water, and such auxiliary equipment as condensers, coolers, exchangers, pumps, tanks, accumulators, etc.

In the operation of the process, untreated oil is charged at a controlled temperature (100° to 200° F.) through a flow controller to the middle of the treating tower. Furfural enters at the top of the tower, at a controlled temperature (up to 300° F.) and flow rate (50 to 450 per cent of the oil charge rate). A gradient (30° to 100° F. or more) between the top and bottom of the treating tower is maintained.

A recent development in the design of furfural refining units has been the elimination of raffinate and extract mix surge tanks. With the simplified flow the treating tower is operated under sufficient pressure from the oil and furfural charge pumps to permit continuous flow of raffinate and extract solutions from the tower to and through a portion of the respective solvent recovery systems where standard types of indicating and control instruments maintain uniform operating conditions.

Mixtures of furfural and water separate quickly into two layers, one of which contains about 90 per cent water and is charged to a water stripper while the other layer contains 90 per cent furfural and is charged to a furfural stripper. A constant-boiling mixture (boiling point 208° F.) consisting of about 35 per cent furfural and 65 per cent water is stripped from each of these layers. These vapors are condensed and returned to the c.b.m. or settling tank for reseparation into the layers which are pumped to the respective strippers.

This process is licensed by Texaco Development Corp., New York.



Phenol

Solvent Extraction

AROMATIC and naphthenic compounds are relatively soluble in phenol, while the paraffinic constituents are rejected selectively. Phenol is used especially to improve viscosity index and stability of the product, and is highly selective, requiring a low percentage of solvent to get the desired result.

Raw charge stock is preheated and sent to an absorber tower at about 235° F., where it picks up phenol from phenolic water passing through the absorber, thence to the treating tower, usually packed, where it enters the lower part of the tower. Passing upward as the discontinuous phase the raw oil gives up nonparaffinic constituents to the phenol. The interphase level is at about 70 per cent of the tower height from the base, and above this level the extracted oil forms the continuous phase, the anhydrous phenol entering at the top and passing downward. Temperature of contact with distillate stocks is about 150°-155° F. at tower top and 110° F. at bottom, with the phenol present in about 60-65 per cent of the oil charge. For residuals the solvent is fed at about 130-140 per cent of the charge, tower top being maintained at 225°-230° F., and the bottom at about 155° F. Water containing about 11 per cent phenol may be added at the tower bottom.

The raffinate emerges from the top of the tower with about 20 per cent of phenol which is preheated and then heated in the furnace to about 550° F. and flashed to remove most of the phenol. The remainder of the solvent is removed in the stripper with steam at about 22 in. of mercury until solvent content is reduced to 0.001 per cent.

The extract solution, containing, when operating on Pennsylvania charge stocks, about 85 per cent phenol, 8 per cent water and 7 per cent extract goes to the drying section of the recovery unit from which an 11 per cent solvent-89 per cent water constant-boiling mixture is taken overhead. The remainder of the solution is heated to 650° F. and flashed in the evaporator, eventually reducing the extract solvent content to about 0.005 per cent.

Neutral oils show considerable improvements in viscosity index, flash, and fire points. More significant is the very high viscosity, carbon residue of the extract, and its low flash and fire tests.

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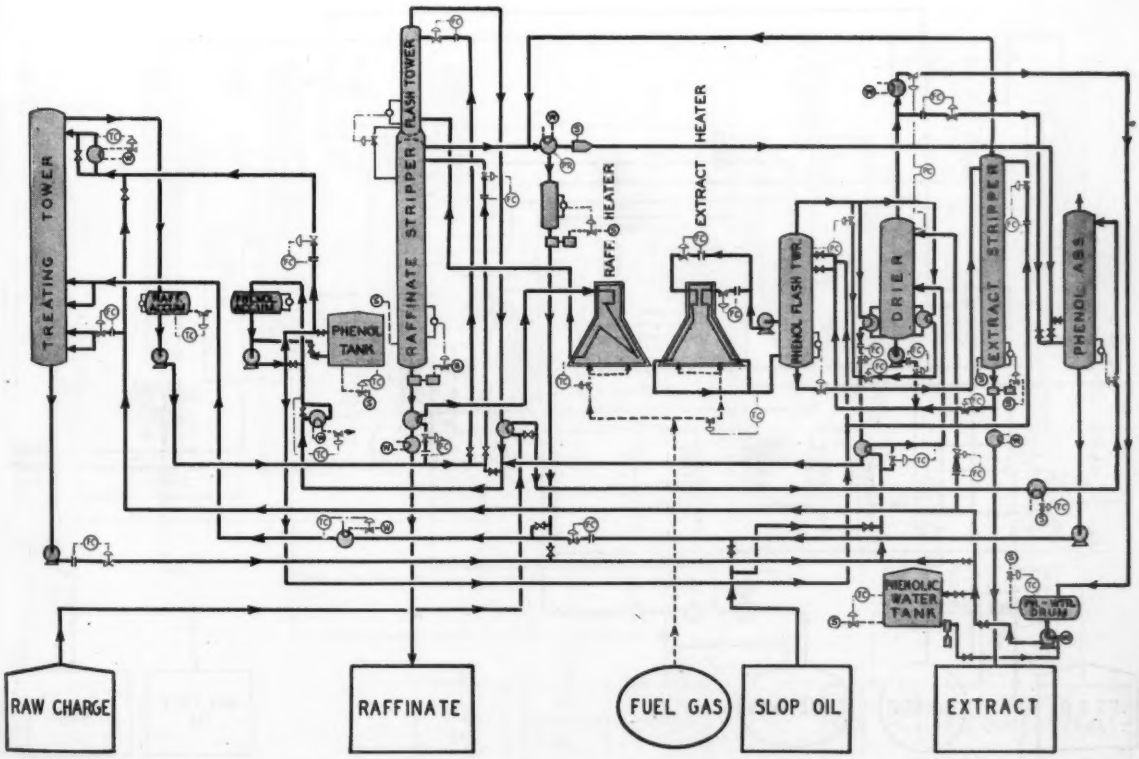

MEK

Solvent Dewaxing

THE ketone-benzol solvent dewaxing process is widely used to dewax distillate or residual type oils to pour points that are equal to or within a few degrees of the dewaxing temperatures.

The equipment required and the controls necessary for smooth plant operation are illustrated in the flow diagram, typical of the process. This shows the wax-bearing oil and solvent streams being mixed under control of a ratio flow controller. Several methods of securing this constant ratio between oil and solvent have been used successfully. The combined oil-solvent stream flows through a system of exchangers and chillers from which it emerges at a controlled temperature which is maintained by regulating the pressure on the refrigerant side of the charge mix chiller. The liquid phase of the charge to the filters is adjusted to the proper filtration viscosity by the addition of chilled solvent to the chilled oil-solvent mixture.

The chilled slurry flows by gravity from the filter feed tank to vacuum filters. A constant liquid level is maintained in the filters by a liquid-level controller.

The filtrate is pumped from the filtrate tank at a controlled rate through the incoming charge exchangers to the solvent recovery equipment. The controls for this portion of the equipment are clearly shown on the flow diagram.

The recovery of solvent from the wax cake is accomplished in much the same manner as in the case of the filtrate except that any water inadvertently entering the oil or solvent side of the dewaxing system quickly finds its way as ice into the wax cake. To remove this water, the wax cake is heated before evaporation of solvent to a controlled temperature of about 130° F. at which the water separates quickly as a water layer.

A recent development has been the production of marketable wax concurrently with the production of low-pour-point oils but conducted in separate equipment as a separate process.

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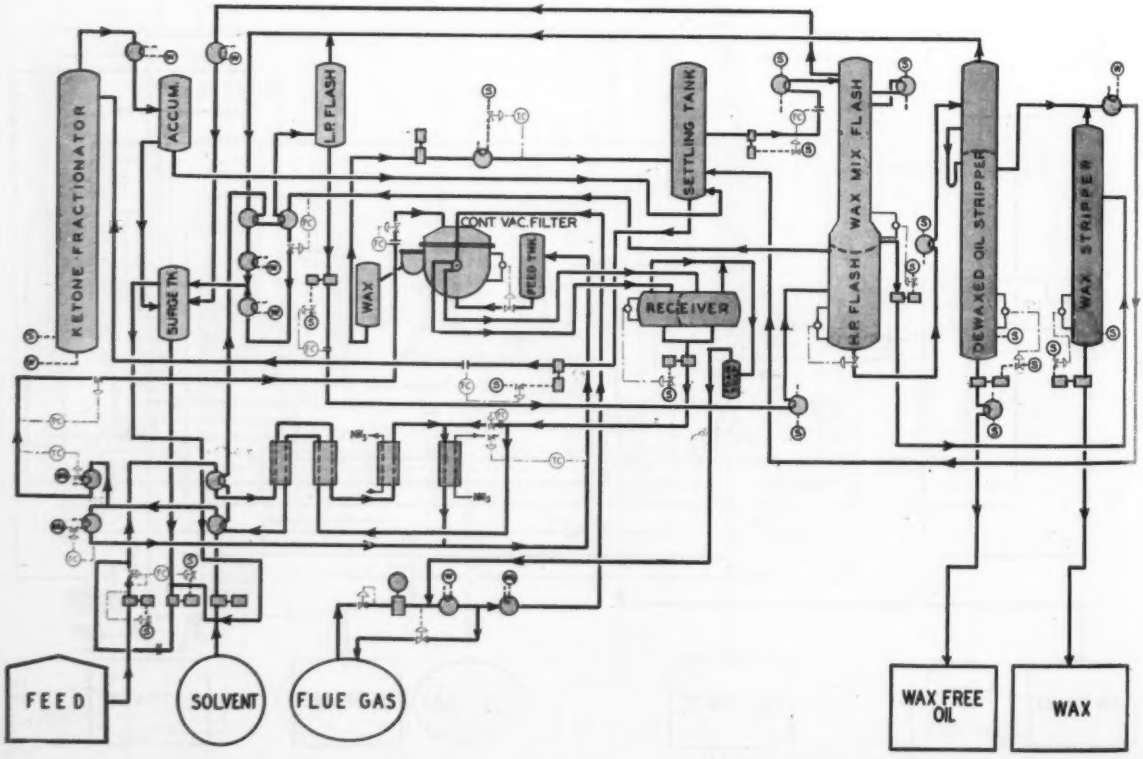


Propane Deasphalting

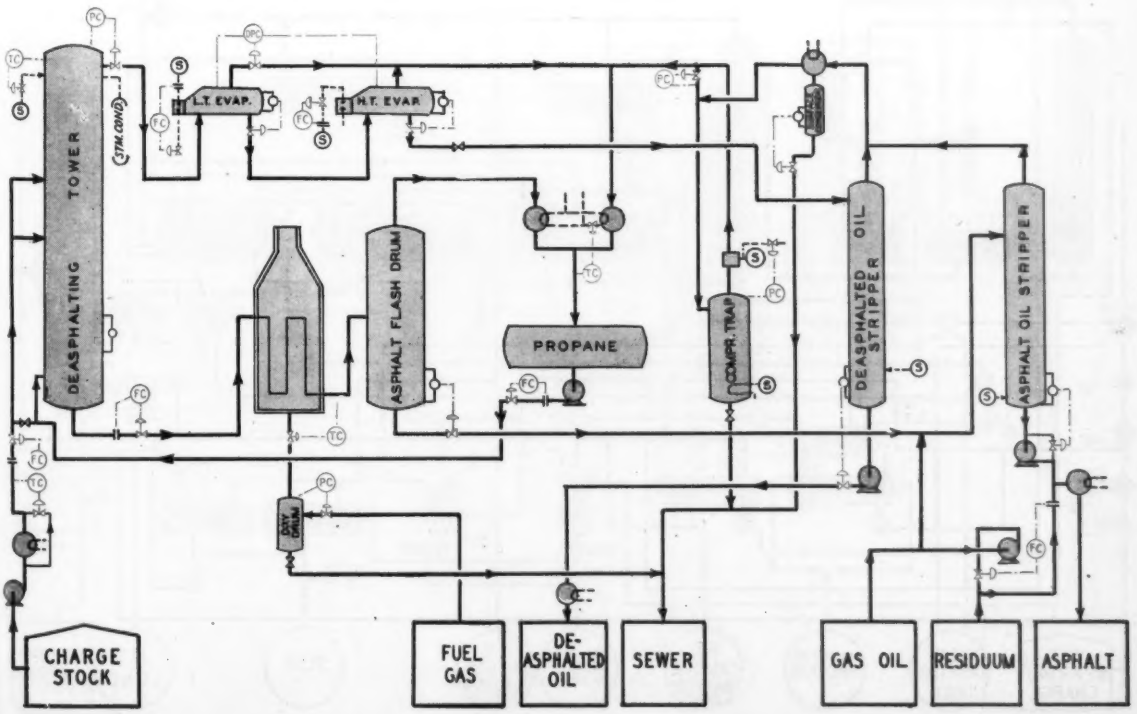
IN carrying out the process, the newer designs utilize a contact tower rather than the older method of bringing oil and propane into contact in a series of stages. Reduced crude is introduced at a point near the middle of the tower, after being preheated to a predetermined temperature, generally below 250° F. Liquid propane enters the tower at the bottom and passes upward countercurrent to the down-flowing oil. As this process continues the oil-propane solution selectively precipitates asphaltic and resinous materials from the raw oil, the solution passes upward, and the heavy precipitate flows downward.

The asphaltic material contains some propane which is removed first by flashing in a drum, then is stripped with steam in a separate tower. This heavy, viscous residue is being applied to industrial and commercial product making. The oil-propane solution is likewise stripped of solvent in suitable towers.

Yields of deasphalted oil may vary in this process from 40-50 per cent to as high as 95 per cent, the yield depending on the asphalt-resin content of the raw charge and the degree to which the deasphalting is carried out. The asphalt so removed may range from 140 to 180 softening point and the oil may show 5 to 7 N.P.A. color. By utilizing the proper combination of temperature, pressure, and solvent ratio the precipitated material may be separated into two fractions, the one highly resinous with little asphalt content, the heavier being mainly asphaltic material.

By choosing the proper conditions and operating sequence this process may be employed to fractionate oil into two or more products, each differing from the other in specific properties. Successive fractions of differing paraffinicity may be so obtained, each of which may be desirable for a given purpose to become a finished product or a part of it. The method has been and is being used as a means of preparing charge stocks for various purposes, such as the purification of heavy residues for charge stock for thermal or catalytic cracking operations. The method may be used as a substitute for vacuum distillation, although the separation is somewhat different.

This process is licensed by M. W. Kellogg Co. New York.



Propane Dewaxing

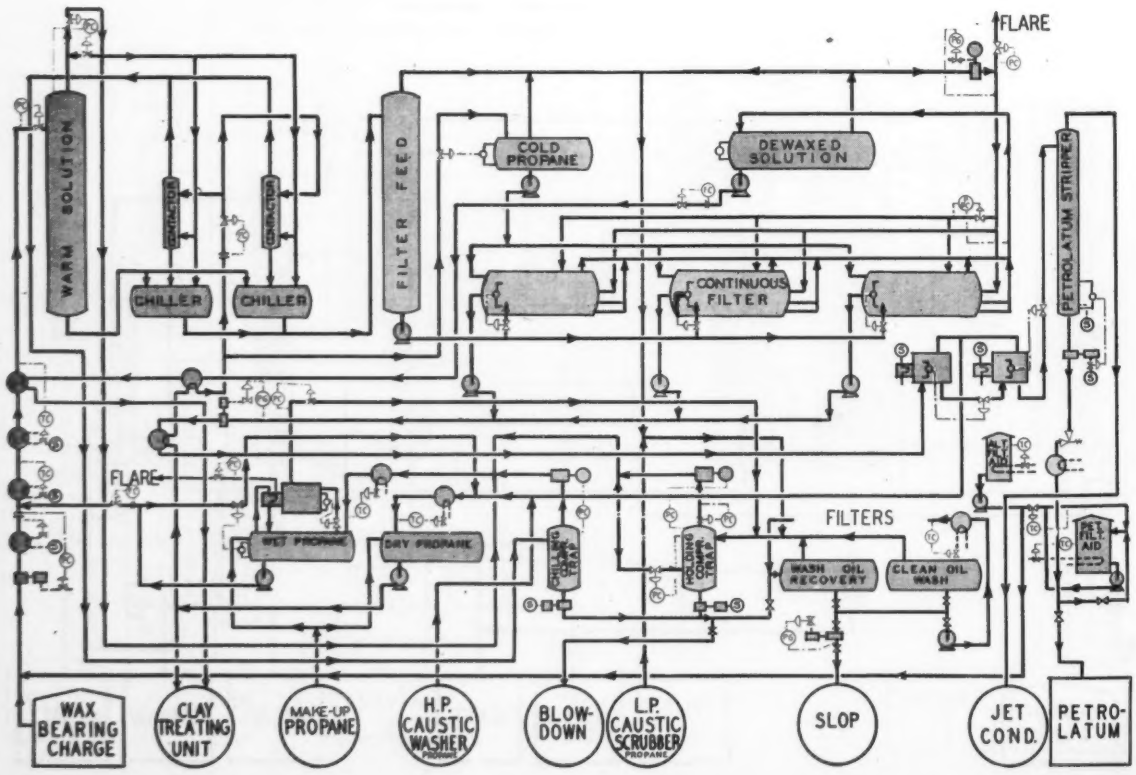
IN propane dewaxing of lubricant fractions, such as cylinder stocks, a typical operation blends three volumes of propane under pressure at 180° F. with one volume of stock; this solution is chilled to 70° F. and sent to chillers where pressure is reduced to evaporate propane until the remaining propane solution is cooled to, say, minus 40° F. Wax crystallizes out of this solution which is passed to and held in filter feed tanks. The filters are rotating-drum type, in which suction is maintained inside the drum which dips below the level of the wax-solution slurry in the filter case.

As the drum rotates slowly the cake forming thereon is washed with cold propane in a stream of jets. The surface of the wax cake is cut continuously from the blanket by a knife as the drum rotates, the crude wax being conveyed to the wax tank. Filter pressures range from 3 to 10 psig. If stock is to be deresined the dewaxed solution is diluted with one to five volumes of warm propane, heated to 140°-180° F., and the resins settled. They are washed with one or two volumes of propane, and the solution is depropanized at elevated condenser pressure and later at atmospheric pressure. A typical dewaxing-deresining loss is about 14 per cent of the charge.

Product improvement is shown for one Bradford residuum in which carbon residue was decreased from 2.33 to 2.19; color determined by optical density measurements dropped from an O.D. of 3,250 to 2,093; most of this color loss was concentrated in the wax, which showed O.D. of 11,970. By deresining the color was reduced to 750, carbon residue to 1.73; viscosity was reduced from 165 S.U.S. at 210° F. to 148.

Over-all solvent loss is reported to range from 0.2 to 1 per cent of that used in the process which, at the low cost of the solvent, makes this expense nominal. Control methods are relatively simple and include liquid levels, proportioning equipment, and pressure and temperature controls.

This process is licensed by M. W. Kellogg Co., New York.



Houdry Dehydrogenation

IN the Houdry catalytic dehydrogenation process the fresh feed, along with unconverted material consisting of n-butane and butenes from the purification unit, is pumped through a heater of conventional design using rate and temperature controllers to maintain the desired conditions. The preheated feed is charged to the catalytic reactors where dehydrogenation occurs.

In order to limit the catalytic temperature variation during the cycle, the heat capacity of the catalyst mass is controlled by utilizing, mixed with active catalyst, an inert material of high heat capacity.

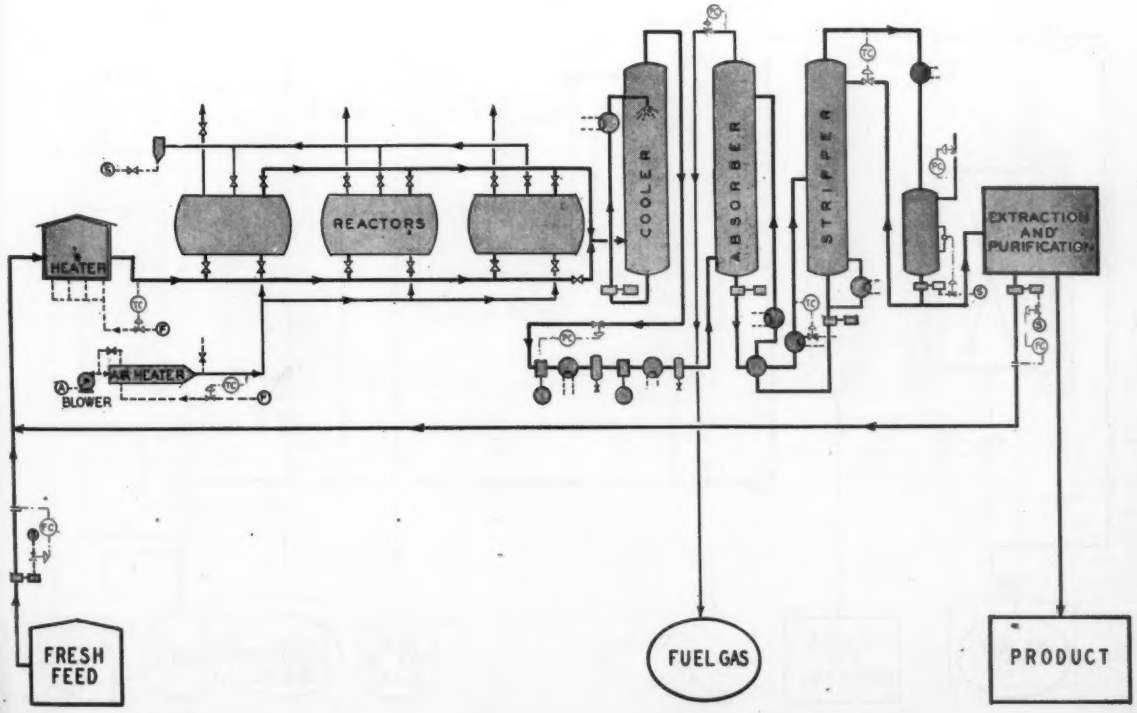
Space velocity, defined as the liquid volume of feed per hour per volume of catalyst, is controlled by the rate of pumping fresh feed and recycle stock.

The pressure is regulated by controllers installed at the suction of the compressors which handle the product vapors. In the dehydrogenation process thermodynamic equilibrium requirements dictate the use of subatmospheric pressure to achieve the desired reactions at practical temperature levels.

Products from the reactor are taken to coolers, usually of the direct quench type, and then to a battery of compressors, where the pressure is raised to the proper level for recovery. When very low absolute pressure is used as in the production of butadiene from normal butane, two stages of compression are used. From the absorber, fuel gas of high hydrogen content is taken overhead while the liquid product stream, butane-butylene-butadiene, is stripped from the rich absorber oil. This cut is then sent to the extractive distillation section where diolefins are separated as finished products, and the unconverted material is returned as recycle.

The continuity of flow is effected by the use of motor-operated valves remotely controlled by a cycle timer which controls their opening and closing at predetermined intervals. Conventional fixed-bed operating technique is employed to attain continuous flow of all streams. Mixing of streams is made impossible by use of electrical interlocks.

This process is licensed by Houdry Process Corp., Philadelphia.



Universal

Isomerization

THE U.O.P. isomerization process catalytically converts normal butane to isobutane. This process can also be adapted to convert normal pentane to isopentane.

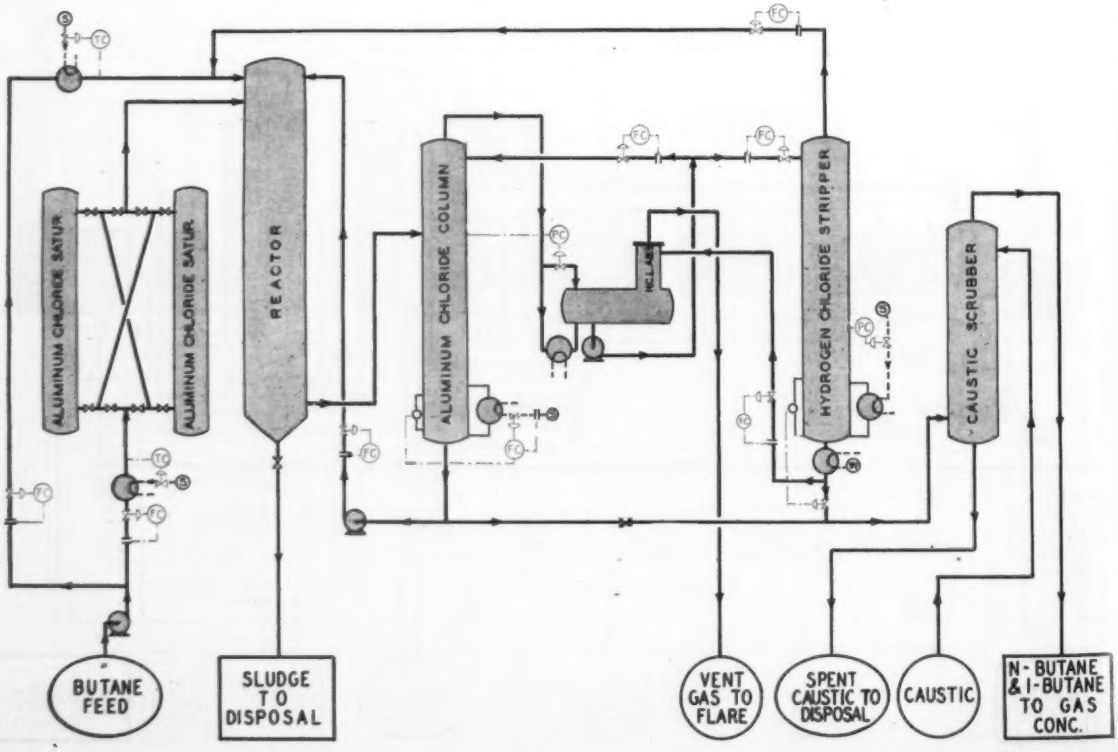
The butane feed divides two ways: one flow goes through a preheater to the saturators; the other, through a preheater to the reactor. Each flow is regulated by a flow-recording controller. The temperature of the saturator preheater outlet is regulated by a temperature-recording controller on the heating medium. This temperature determines the amount of aluminum chloride dissolved in the butane going through the saturator. The reactor preheater outlet is also regulated by a temperature-recording controller. This temperature is so controlled that the blend of the four streams coming to the reactor will have a fixed temperature as shown by the temperature recorder in the top of the reactor bed.

The aluminum chloride column pressure is regulated by a pressure recording controller on a vapor bypass around the condenser. The level in the bottom of the column is regulated by a liquid-level controller resetting a flow-recording controller on the reboiler heating medium. A small drag stream carrying pentanes is drawn off manually from the bottom of the column to the caustic scrubber. A recycle bottoms stream carrying aluminum chloride back to the reactor is regulated by a flow-recording controller. Light gases that accumulate in the receiver are vented off through the HCl absorber which recovers HCl that is present. Isomerization product is used for absorption oil and is regulated by a flow controller.

The hydrogen chloride stripper overhead is recycled back to the reactor through a flow-recording controller. Temperature indicators on the stripper indicate the hydrogen chloride inventory in the column. The pressure on the column is regulated by a pressure recording controller resetting a flow-recording controller on the heating medium.

The role of anhydrous hydrochloric acid in this catalytic process is an important one. HCl is added to the reactants in this process, but is also one of the decomposition products formed from anhydrous aluminum chloride during its reactions with hydrocarbons. The isomerization reaction appears to be inhibited when a hydrocarbon is in contact with $AlCl_3$, until at least a small portion of HCl is formed by side reactions and its presence activates or "promotes" the isomerization reaction.

This process is licensed by Universal Oil Products Co., Chicago.



Universal Dehydrogenation

THE U.O.P. dehydrogenation process removes hydrogen catalytically from hydrocarbons, particularly butanes, to produce olefins and diolefins. For simplification only two reactors are shown. The catalyst in one reactor is undergoing reactivation while the catalyst in the other is in process.

The butane charge to the heater is regulated by a flow-recording controller. A small recycle stream picks up sulfur to act as a pacifier. A temperature-recording controller on the transfer of the butane heater regulates the firing. In case the butane flow through the heater is interrupted, the differential pressure-recording controller across the heater will shut off all of the fires except the pilot lights.

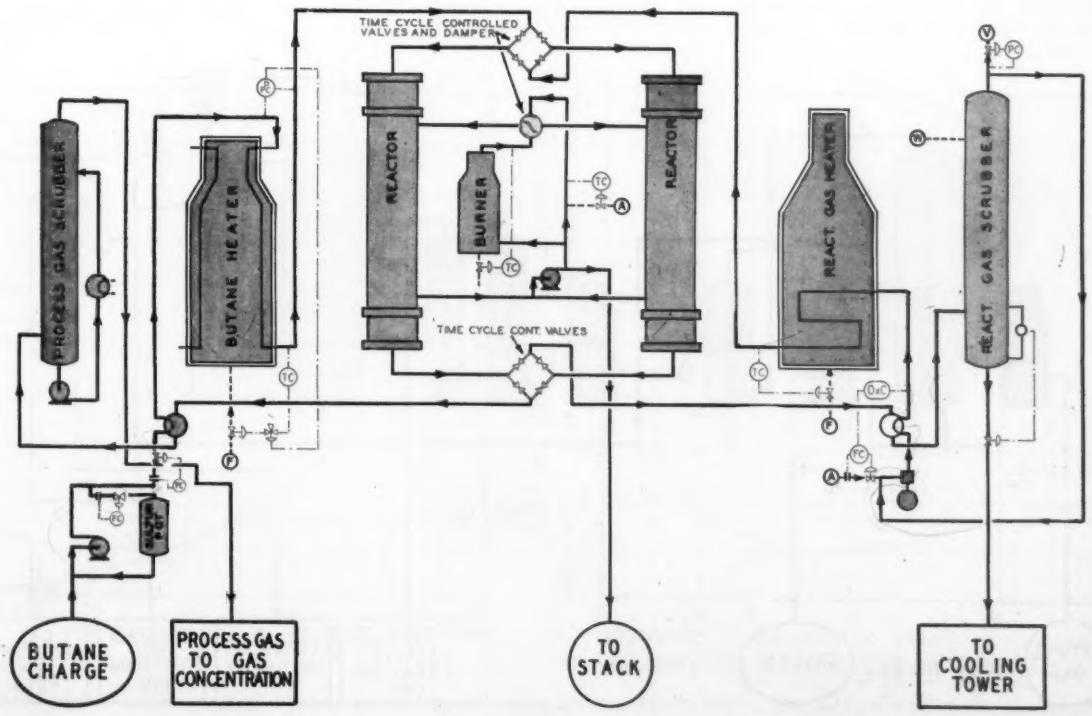
An automatic time-cycle controller periodically switches the reactors through a cycle of processing, purging, and reactivation. If any valve fails to meet its scheduled performance, interlocking controls halt the switching cycle and sound an alarm.

Externally circulated flue gas maintains fixed temperatures in the reactors by removing the heat of combustion from the carbonized catalyst during reactivation, and by supplying the heat of reaction to the gas stream during processing. The draft on the discharge of the flue gas circulating fan is automatically controlled by adjustment of the stack damper. A gas-fired burner controlled by the outlet temperature, heats the hot duct flue gas going to the processing reactor. The temperature of the cooling duct flue gas going to the reactivating reactor is maintained constant with admission of cold atmospheric air by a temperature-recording controller.

The hot process gas leaving the reactor is scrubbed and cooled by contact with cold oil and goes to the gas concentration unit for fractionation.

The reactivating gas leaving the reactor is cooled and washed by a water scrubber and is recirculated back to the reactivating gas heater. A high-temperature alarm on the scrubber warns if the circulation of cooling water is interrupted. The venting of excess gas is controlled by a pressure-recording controller. The wash water returned to the cooling tower basin is regulated by means of a liquid-level controller. The oxygen content of the reactivating gas is regulated by the oxygen-recording controller. A controlled oxygen content is maintained in the reactivating gas to prevent excessively high burning temperatures. The transfer temperature of the reactivating gas heater controls the firing rate.

This process is licensed by Universal Oil Products Co., Chicago.



Hydrocol

THE Hydrocol process has been developed for the production of premium-quality gasoline, diesel fuel oil, and other products of value by the catalytic reaction of carbon monoxide and hydrogen over a cheap, rugged, efficient catalyst in a fluid bed. The starting material may be oxygen from the air and practically any carbonaceous substance, such as natural gas, coal, heavy crude oil, or fuel oil. Using natural gas the preparation of the carbon monoxide and hydrogen proceeds as follows:

$$CH_4 + \tfrac{1}{2}O_2 = CO + 2H_2$$

In this reaction the hydrogen and carbon monoxide are in the desired ratio for the subsequent synthesis step. When using material deficient in hydrogen it is essential to add steam to the generator to supply the hydrogen deficiency.

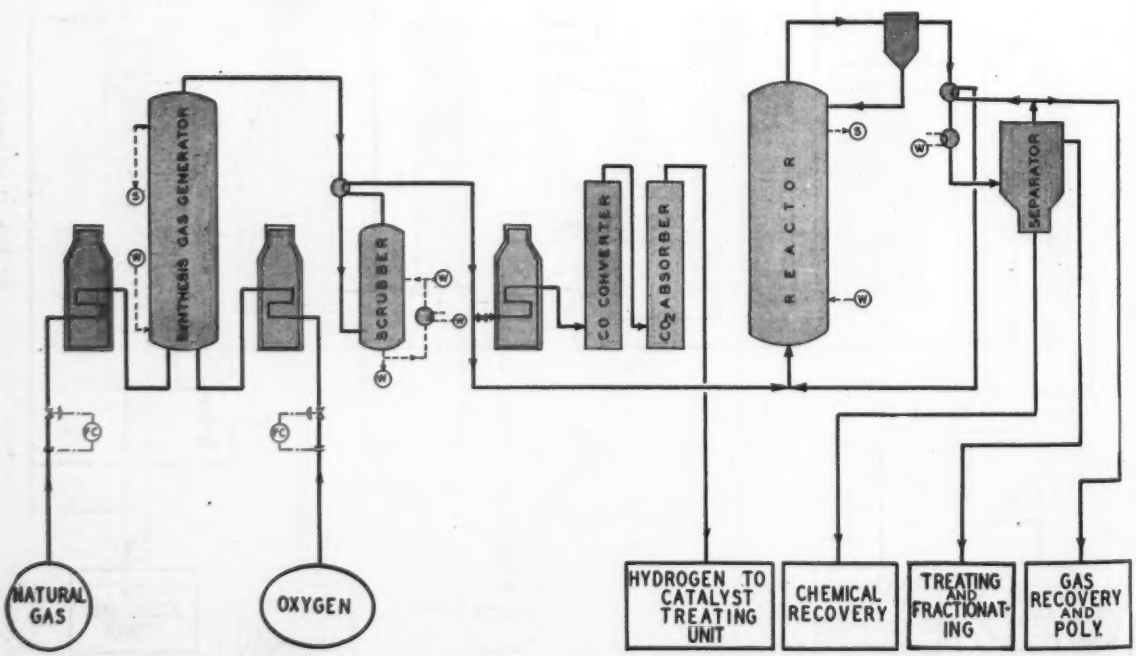
Because of the exothermic nature of the reaction of natural gas with oxygen and the exothermic nature of the catalytic reaction of carbon monoxide and hydrogen, it is possible to produce all of the steam required for the auxiliary processes, including oxygen manufacture, fractionation, absorption, polymerization, treating, and catalyst reworking.

The gasoline produced in the synthesis step contains a small per cent of residual byproduct oxygenated compound; these are removed and the gasoline fractionated. When blended with gasoline formed through polymerization of the off gases of the synthesis step, there results a product of superior quality as evidenced from the following representative tests:

Gravity, °A.P.I.	66.4
C.F.R.M. octane, clear	79.2
C.F.R.R. octane, clear	90.9
R.v.p. at 100° F.	9.2

Development of the Hydrocol process, using natural gas as the raw material, has brought it in line competitively today with the more conventional refining processes, such as catalytic cracking, using petroleum, for the production of high grade motor fuels. Development work now in progress indicates that the process may be made competitive even when employing coal as the raw material.

The Hydrocol process has been developed by Hydrocarbon Research, Inc., and is licensed by Texaco Development Corp., New York.



Greater Trend Toward Petroleum Performance Specifications in 1947

*by C. M. Larson**

THE long-standing method of stating the physical and chemical properties of petroleum products capable of being measured in any laboratory by standard methods of tests, called physical specification, is giving way to performance specifications. Performance specifications require a statement or guarantee of future performance in service or in "life tests" under actual or similar conditions. A special subcommittee on oil-purchase specifications of Committee D-2, A.S.T.M.[1] reported that "there is not nearly enough reliable information now available as regards test methods to permit workable oil-purchase specifications which would, within themselves and without performance tests, serve as a reliable guide in the selection of lubricants." Laboratory tests are not safe guides to service performance.

Today the great bulk of fuels and lubricants consumed are required to meet some sort of service performance standards. This makes it necessary to determine desired standards of performance for particular classes of equipment and operating conditions. The petroleum supplier then is required to meet these performance standards with an approved product whose quality, suitability, and uniformity are warranted or certified. This new phase of consumer purchase outmodes the purchase of various refiner's neutrals and bright stocks and adding certain additives to the blend. Such finished products made from different sources of neutral and bright stocks would lack service performance records and would vary in their demerits when compared with the approved samples on the original equipment performance test apparatus.

In order to see how this trend toward performance specifications affects the crude used, the refining process, and addition agent required, let's take the larger and more important service requirements of fuels and lubricants. Also the newer mechanical trends and their need for specialized petroleum characteristics.

*Chief consulting engineer, Sinclair Refining Co., New York, N. Y.

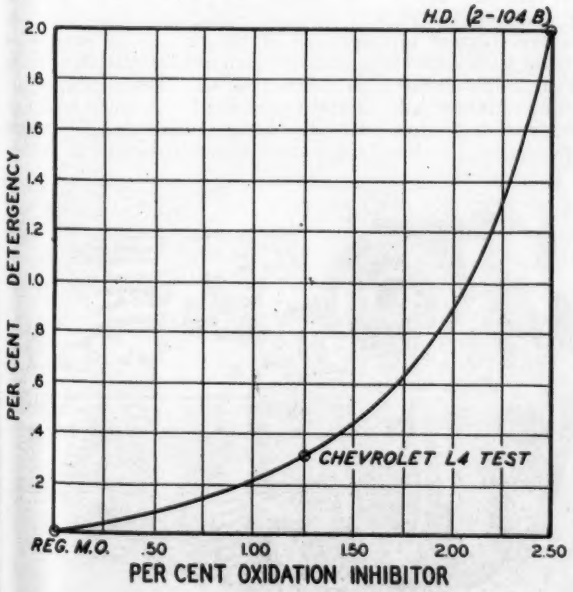
Passenger Cars, Trucks, Buses

Motor oils.—In both gasoline and diesel engines, long operation, without necessity of shutdown or premature overhaul, is essential. Freedom from piston lacquer, stuck rings, crankcase sludge, plugged oil screens, and corroded bearings is demanded. The leading automotive engineers, as well as those of the research laboratories of large oil companies, all demonstrate that only actual engine operation will determine the characteristics of motor oils. To meet these various operating conditions, the lubrication committee, Division of Marketing of the American Petroleum Institute, have refined motor oils as follows:

Regular type.—This term designates motor oil generally suitable for use in internal-combustion engines under moderate operating conditions.

Premium type.—This term designates motor oil having the oxidation stability and bearing-corrosion-preventive properties necessary to make it generally suitable for use in internal-combustion engines where operating conditions are more severe than regular duty.

Heavy-duty type.—This term designates motor oil having the oxidation stability, bearing - corrosion - preven -



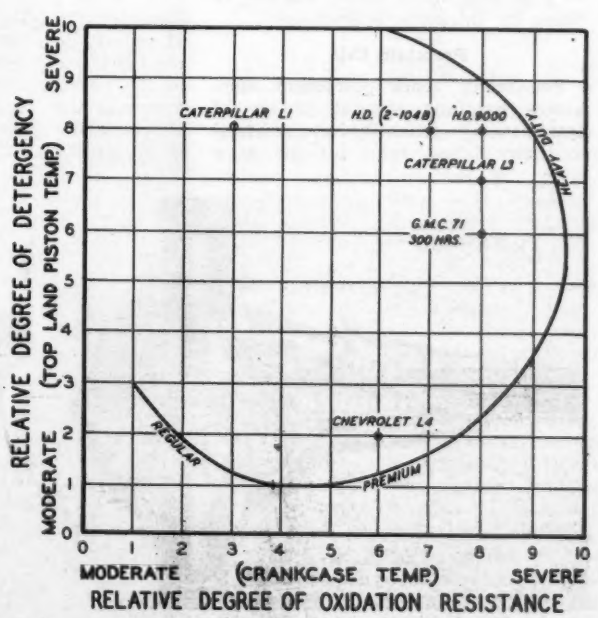
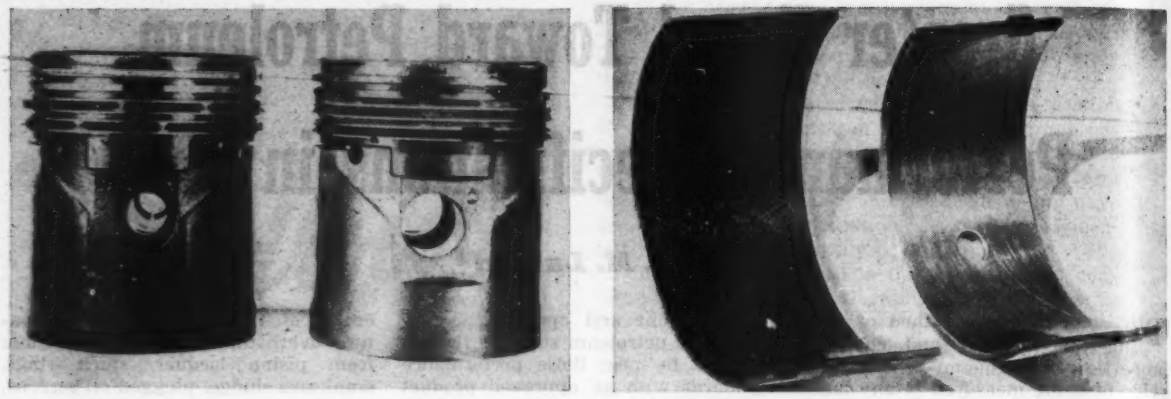


Fig. 1—(Left) Relative oxidation and detergency requirements of engines and oils. Fig. 2—(Right) Example of amount of oxidation inhibitor and detergency necessary to pass Chevrolet L4 and heavy-duty 2-104B tests



Figs. 3 and 4—The piston and bearing shown at left in the photographs were operated with poorly refined oils; those at right with modern premium-type oils

tive properties, and detergent-dispersant characteristics necessary to make it generally suitable for use in both high-speed diesel and gasoline engines under heavy-duty service conditions.

As an example, oils that meet the engine tests requirements of U. S. Army Specification 2-104B or the U. S. Navy Specification 14-O-13A commonly known as the 9000 series, are classified as heavy-duty-type motor oils.

Today the monthly consumption of the heavy-duty-type motor oils in trucks, buses, and contractor equipment, is more than 8,000,000 gal. per month, whereas, that of the new premium-type motor oil in passenger cars and trucks is well over 30,000,000 gal. This premium line fits about 85 per cent of the market both for passenger cars and gasoline trucks, as well as high-speed diesel engines in buses in intracity operations.

Premium Oils

For many years petroleum marketers handling several grades of crankcase oils generally have referred to their highest price product as a premium oil. With the adoption of the A.P.I. nomenclature and definitions, the term "premium" assumes a new meaning. It now refers to outstanding performance characteristics.

No restrictions as to the source of the oxidation inhibitor are placed by the A.P.I. definitions on either the premium or heavy-duty-type motor oils. By carefully selecting the crude sources and refining processes, it is possible to obtain a much higher degree of natural resistance to oxidation than would normally be expected; however, straight mineral motor oils become corrosive and form engine deposits under severe operating conditions, and like the oils containing less natural resistance to oxidation, are greatly improved through the use of additive compounds.

Whether the premium-type motor oils contain an oxidation inhibitor only, or an oxidation inhibitor and a detergent-dispersant compound, will, of course, depend to some extent on the marketer's viewpoint with respect to the necessity for including detergency in this type of crankcase oil. However, the solvency and dispersant characteristics of the particular inhibitor employed and the degree of refinement of the base oil, determine the advisability or desirability of including detergency in the premium-type grade.

The range of premium-type quality can vary from just above high-v.i. regular type to that approaching heavy-duty-type properties.

Fig. 1 shows the effects of various increasing percentages of antioxidant and detergency to meet the requirements of the Chevrolet 36-hour C.R.C. L4 test upward to those engine tests to meet U. S. Army 2-104B specification. Fig. 2 is a plot of the relative crankcase-oil temperatures from moderate to severe conditions in relationship to the top land temperatures graded from moderate to severe. The requirements of regular, premium, and heavy-duty-type motor oils also are indicated as they fit this increasing engine load and service demand. It will be noted that too great an amount of detergency to counteract excessive piston ring sticking, tends to depreciate the antioxidant characteristics of the heavy-duty-type motor oils. Thus engine design, engine application, and differences in opera-

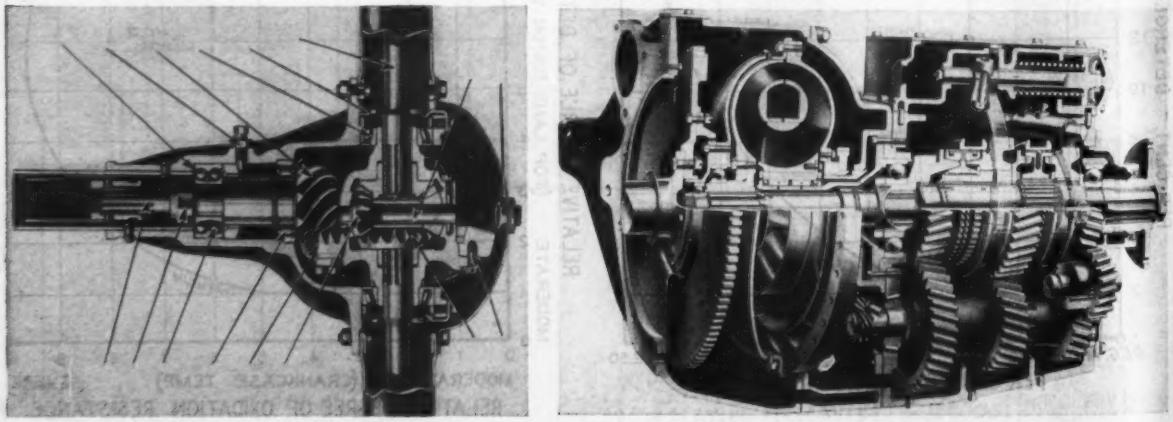


Fig. 5—(Left) Passenger-car hypoid axle using the new all-purpose 2-105B gear lubricant, S.A.E. 90 grade, which is also suitable for trucks. Fig. 6—(Right) White Motor Co.'s 1947 Hydrotorque-drive transmission which uses special torque-converter lubricant

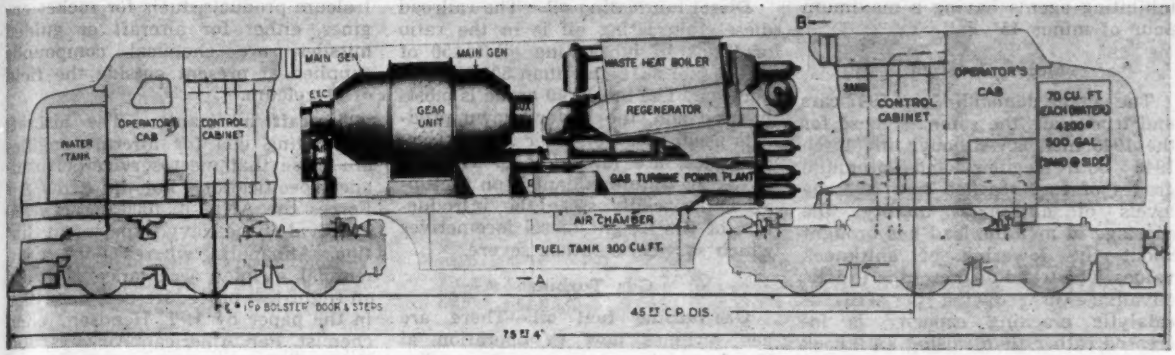


Fig. 7—General Electric gas-turbine-locomotive layout which is to use No. 6 fuel oil

tion vary the demands of proper additive proportions to give clean engines.

Gear Lubricants

At the June 1946 S.A.E. meeting at French Lick, Ind., the statement was made in a paper[3] that the only suitable test to determine whether or not a gear lubricant will lubricate a passenger-car hypoid axle satisfactorily at high speeds is to put the lubricant in the axle and run the car at high speeds. The other passenger-car manufacturers have come to the same conclusion. They have agreed, however, that the best solution to their problem is the performance specification U. S. Army 2-105B, universal gear lubricant and such all-purpose gear lubricants are satisfactory for the bulk of the passenger cars and trucks. The base oil for these 2-105B gear lubricants are of high viscosity index and are generally very stable. The source of additives are restricted and because of the fat situation, very expensive. As a temporary measure the Federal Specification VV-L-761 is being revised; however, by the end of the year marketers will lean more to the 2-105B performance specification of approved products as self protection both for rear axles and transmissions of passenger cars and trucks. The motor-car and truck manufacturers will insist on 2-105B all-purpose gear lubricants.

There are some heavy-duty trucks and buses that recommend only straight mineral oils of 95 v.i. minimum for the transmissions and rear axles. These are of the high-v.i. regular-type motor-oil designation.

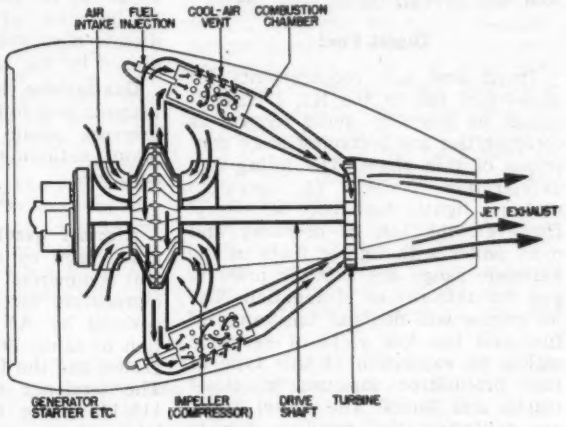
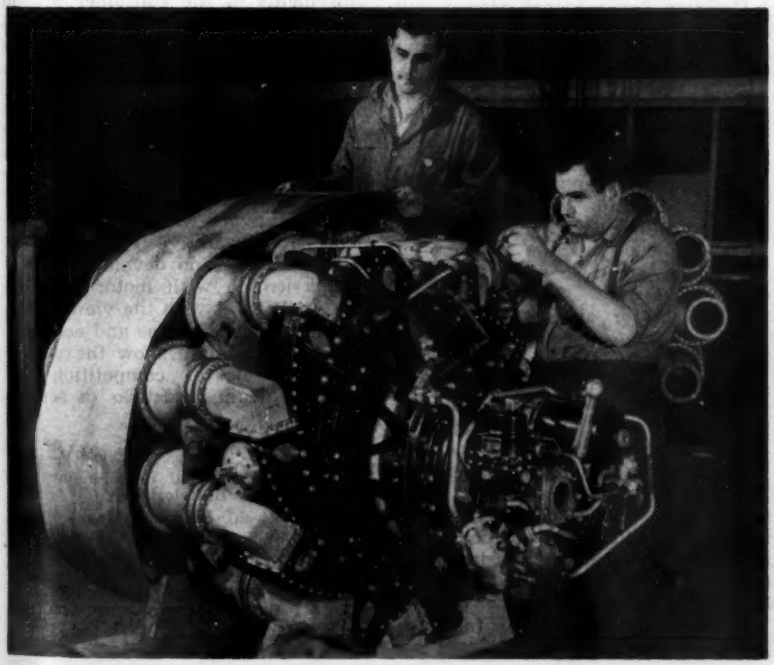


Fig. 8—(Below) General Electric's turbo-jet power plant

Fig. 9—(Right) Diagram of G.E. turbo-jet which uses jet fuel and special lubricant



Fluid Couplings and Torque Convertors

The fluid coupling, also called "fluid drive," "fluid flywheel" or "fluid clutch," is the basic hydraulic mechanism in several passenger-car hydraulic transmissions. The trend in future design is toward this drive. In the truck, bus, and bulldozer drives, the torque convertor is going to come into more extensive use during 1947.

The hydraulic fluid used in a fluid coupling consists of a high-v.i., highly refined mineral with subzero pour, blended with antioxidant antifoam additives to impart a number of necessary but rather special service performance qualifications. The viscosity of the fluid should be as low as is consistent with complete lubrication of the bearings, gears and the coupling seal. The high v.i. must not be affected by high rates of shear.

The torque convertor or hydrotorque transmissions requires a highly refined mineral oil of 175 to 195 S.U. viscosity at 100° F., 90 minutes v.i. containing antifoam and oxidation

inhibiting agents having a maximum pour of minus 15° F.

Motor Gasoline

The octane demand of the 1947 cars and trucks are the same as those for the 1946 models. Although in March 1946 both regular and premium grades of fuel reached new average levels of antiknock quality, the shortage of metallic lead has brought about the lowering of antiknock values. The trend at present is to take advantage of reducing the TEL as catalytic cracking capacity is increased rather than raising antiknock quality. The predictions are that 1948 cars to start production near the end of the year, will bring back antiknock requirements to that which would have prevailed had there been no shortage of lead or a C.P.A. order imposing a limit of 80-octane number by the A.S.T.M. method on the antiknock quality of motor gasolines. The high percentage of premium gasoline sold will prevail throughout 1947.

Diesel Fuel

Truck and bus requirements for diesel fuel fall in the No. 1 classification in order to avoid smoke, as communities are becoming more conscious of this phase. The idling and deceleration periods of operation makes a lighter fuel more necessary. However, the loss of economy and more smell with lighter fuels in the kerosene range are a bitter price to pay for this smoke elimination. The jet engine will demand this range of fuel and the low yield of kerosene makes an expansion of this type of fuel prohibitive for use in diesel trucks and buses. The diesel buses are replacing the gasoline vehicle in all cities.

Railroad Diesel Locomotives

Diesel fuel.—The marked increased trend of railroads towards diesel motive power has taxed the refiners in certain areas to furnish enough diesel fuel. The demands for 50 cetane have now been lowered to 45-cetane number minimum. The start of the year showed a demand from this source of over 15,000,000 bbl. a year. Such roads like the Gulf, Mobile, & Ohio Railroad will be totally dieselized at the end of the year and others, like the Union Pacific, will more than treble their demands of diesel fuel. The future seems to require higher initials and end points up to 675° F. By 1950 it is predicted that the railroads will need 30,000,000 bbl. of diesel fuel which is equal to all other demands at present. Diesel fuel will have to compete with heating oil, jet fuels, and kerosene demands, all from the distillate range. Of the diesel-fuel additives for improving cetane and engine performance amyl nitrate up to ¼ per cent is practical and has the best case history for this purpose.

Diesel lubricating oil.—The railroad diesel lubricating oil is in the ratio of 1 gal. of lubricating oil to 50 of diesel fuel or, better than 300,000 bbl. per year. The S.A.E. 40 grade is mostly used and, the better-known products used, based on their service performance, are low-v.i. oils. The use of detergent antioxidant is on the upgrade especially since the introduction of the freight diesel locomotives which service is rather severe.

Gas Turbines

Gas-turbine fuel oil.—There are gas turbines now in operation at Houdry high-octane-gasoline refineries. These start on heating oil and use the waste heat from reclaiming the catalyst through burning off the carbon. The trend of gas-turbine design seems to be toward use in railroad locomotives. For this purpose the No. 6 fuel oils and heavy residual fuels are most considered. This gas-turbine development in railroad service is one for 1948 to 1950, particularly in view of the excellent type diesels now available and being acquired by the railroads.

Gas-turbine lubricants.—These lubricants will follow those of the high-pressure steam turbine with antifoam, antioxidant and noncorrosive additives.

Aircraft

Aircraft gasoline.—The present grade used by the Army Air Forces and commercial airlines for their reciprocating aircraft engines, is that covered by AN-F-48 or a modification of same, and covers the 100/130 grades and the 115/145 grades of fuel. The tendency toward more use of 115/145 grade by the Air Force is taking form.

Gasoline for personal planes will have to resolve itself around the regular motor gasoline. An average local airport with 10 to 20 personal planes would only require as much gasoline as a garage with the same number of cars. This makes it impossible to distribute locally special aviation fuels for personal-plane use. The vapor pressure of regular gasolines could be adjusted with engine design of future make so the problem of vapor lock would be nil in this type of plane usage.

Jet fuels for aircraft. — The new proposed A.N.A. specification for jet fuel allows for greater use of gasoline constituents and also cut into the front end of diesel fuels. The end point will be raised above 550° F. The demand for jet fuel will increase to sizable quantities by the end of this year. The higher end point complicates the blends as certain waxes are found in these ends which make it difficult to meet the freezing point of minus 76° F. with certain wax-bearing crude oils.

Rocket fuels.—While the fuels for jet-propelled aircraft are selected petroleum products, fuels for rocket engines, either for aircraft or guided missiles, are chemical compounds supplied at present outside the field of petroleum.

Aircraft lubricants. — The aircraft lubricating oils for aircraft engines are those that meet service-performance specifications. For the Army Air Forces the AN-O-8, 1000 series need approval at the Navy Experiment Station, Annapolis, whereas, the commercial airlines acceptance is based on flight-test procedure best described in the paper by J. T. Hendren,[3] chief chemist, Pan American Airways, Inc. Such flight tests must be obtained through CAA permission before flight testing a new product in an airline. For personal-plane engines either the premium motor oil or the heavy-duty-type detergency motor oil will be used. The premium type will be in 1-qt. and 5-qt. cans, whereas the heavy duty is a drum-distribution item. Such personal-plane engines with alloy bearings cannot use aircraft oils meeting AN-O-8 specifications because these oils are corrosive to such bearings.

Jet-engine lubricating oil. — The amount of lubricating oil for jet-propelled planes is very small and is primarily for antifriction bearings. At first the use of No. 3580 hydraulic (petroleum base) type oils was used. Later a new oil specification No. 3606 (oil, low-temperature lubricant with antioxidant) was put in service but this was not as satisfactory as No. 3580. The Navy symbol 1065[4] oil is being used in the PC-180 type, but at high altitudes it is necessary to heat this oil. The antifriction bearings run a peak of 400° F. temperature.

Upon reviewing the foregoing requirements of the consumer and to meet his equipment demands, it is clear that with the possible exception of railroad diesel lubricating oils, the need for higher v.i., more-stable-base oils are essential to give the desired service performance with the minimum amounts of additives to do the job. Better dewaxing is necessary to prevent pour reversion. Solvent-treated base oils will be much in evidence in all additive-type lubricants. Much research and development will be carried on with motor gasolines and diesel fuels with the view of better engine performance and economy. The year 1947 will show the way to a new cycle of competition and new petroleum yardsticks of service.

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3. "Airline Oil Procurement Practices," Symposium on Oil Procurement Practices, A.S.T.M., Buffalo, N. Y., June 1946.

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Separation Plant

Reclaims Oil From Athabaska Sands

by W. E. Adkins

DECLINING crude oil production in Alberta, notably in Turner Valley, has once more focused public attention on the huge reserves of oil in Alberta's famous oil sands. The Alberta Provincial Government, realizing the necessity of developing new sources of crude oil, has for the past 2 years been sponsoring the erection of a semicommercial separation plant and refinery on the deposits and despite holdups due to shortages of material and labor it is expected that construction on the project will be completed this year. It has long been felt that these vast deposits were not receiving the attention that so large a potential source of oil merited.

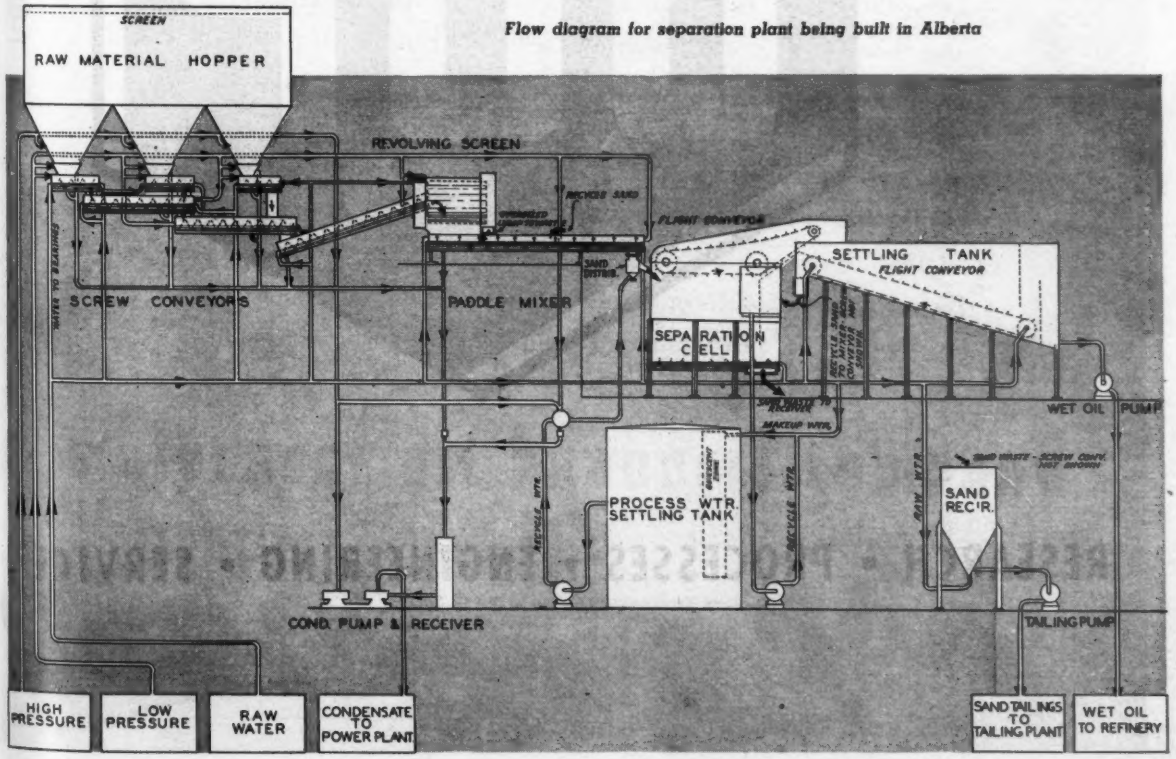
Containing reserves variously estimated at from 100 billion to 500 billion bbl., the oil sands have been the object of several attempts at commercial exploitation over the past 25 years. These attempts have all fallen short of their goal due chiefly to financial difficulties.

Covering a vast area in northeastern Alberta the deposits center on the historic settlement of Fort McMurray at the junction of Clearwater and Athabaska rivers. Travelers on the Athabaska have for years been impressed by the high banks of oil sand along the deep river valley. Cretaceous in origin, the deposits consist of almost pure silica sand saturated with a heavy (10° A.P.I.) crude oil. In many localities oil content is 15 to 18 per cent by weight and these sands yield well over a barrel of oil per cubic yard. While some of the deposit is overlain by heavy overburden there are large tracts where overburden is very light and can easily be removed by dragline, bulldozer, or similar means. Since the sands are deposited on top of the Devonian lime the depth of the beds more or less follows the rise and fall of the limestone strata.

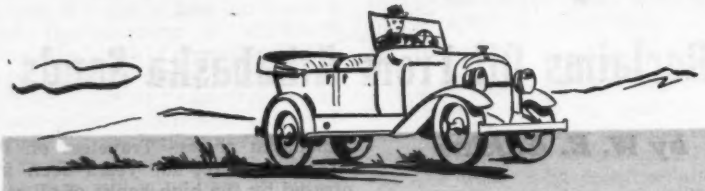
At Bitumount, approximately 55 miles north of Fort McMurray, conditions ideally suited to development exist. Overburden is light and the quality of the sand is high, also the

W. E. Adkins, technical head in charge of the oil-recovery work on Alberta oil sands, is a graduate in chemical engineering from University of Alberta, with several years' experience in the construction and operation of oil refineries and chemical plants in Canada. For 10 years he has studied the problem of recovery of oil from the vast Canadian oil sands deposits and for the last 4 years has engaged in development work to determine suitable recovery methods, which are being applied in the unit discussed in this article.

Flow diagram for separation plant being built in Alberta



More than 30 years of



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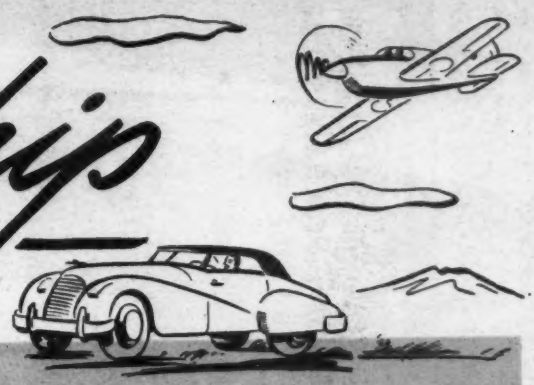

More than thirty years ago, in a small laboratory at Independence, Kansas, a group of UOP technologists were working on what was to revolutionize the refining of crude oils. The result of their labors was the UOP Thermal Cracking (Dubbs) Process...a process that added a new chapter to the history of petroleum refining.

From that day forward, UOP has maintained the leadership which they established with that momentous discovery. New processes... new inventions... new developments... have come out of the UOP laboratories during these fruitful years, making possible the doubling of gasoline yield per barrel of crude and the continuing improvement of gasoline to its present day quality. And hundreds of UOP units... comprising eleven different processes or combinations of processes ... have been installed in the United States and 27 foreign countries.

Today, as always, UOP is dedicated to the further development of refining processes in an unceasing effort to provide even greater efficiency in gasoline production...higher product quality ... and lower operating costs. And, as in the past, these new developments, as they are proved commercially practical, will be made available to refiners all over the world.

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Separation plant and raw-materials hopper with Athabaska River in background. The original pilot plant may be seen in right background

beds are relatively thick. The limestone which is visible above the river at McMurray and farther north form a syncline in this locality dipping from a point 4 miles south and reappearing about 4 miles north. Thus the limestone was encountered at 155 ft. in a test well drilled south of Bitumount, while farther north and east the limestone was nowhere encountered and in the most easterly well the tools were still in oil sand at a depth of 292 ft.

Here, Oil Sands, Ltd., a pioneer in the development of oil sands, has operated a pilot plant which in 1944 separated oil satisfactorily at the rate of 150 bbl. per shift. Based on its background of experience in this field the company was engaged by the Alberta Provincial Government to build a separation plant and refinery to be erected on the company's leases at Bitumount and employing the company's patented process.

The primary objective of the new project is to establish definitely the cost of separating a barrel of oil and secondly to accumulate sufficient technical and operating data to permit the design and construction of a large plant should this prove to be economically feasible. It should be pointed out that the pilot plant of Oil Sands, Ltd., was built purely to prove the process. Economy of operation was a secondary consideration. Much of the equipment was makeshift, having been fabricated in the field as the process developed. The new plant will be adequately housed and every precaution has been taken in the design to prevent loss of heat, oil, etc.

Before actual construction was started, test shafts were sunk to determine the best possible location for the mine. The site finally chosen is on top of the river bank approximately 65 ft. above water level. The steep bank exposes oil sand over almost its entire height of 65 ft. and a test well at water level showed another 100 ft. of good-grade sand, so that an adequate supply of well saturated sand under light overburden is assured.

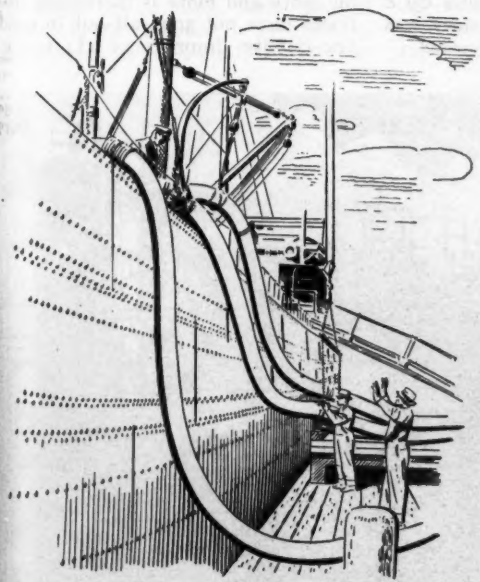
Samples taken over the exposed 65 ft. analyzed as follows:

Sample No.	Location	Oil	Water	Mineral matter
1	Top 6 ft.	12 %	....	....
2	Middle	14.7%	0.7%	84.6%
3	Bottom	15.3%	1.0%	83.7%

(Continued on page 231)

Excavating oil sand with power shovel and dump trucks

When you need a trouble-shooter...



Call this man! He's your Oil Equipment Supply Specialist. And he's always available to help find the answer to your problems.

He knows, for example, the kind of beating that oil suction and discharge hose has to take in loading and unloading operations.

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When you need a trouble-shooter for *any* oil-handling problem, call your Oil Equipment Supply Specialist. His knowledge and experience will save you time and money.

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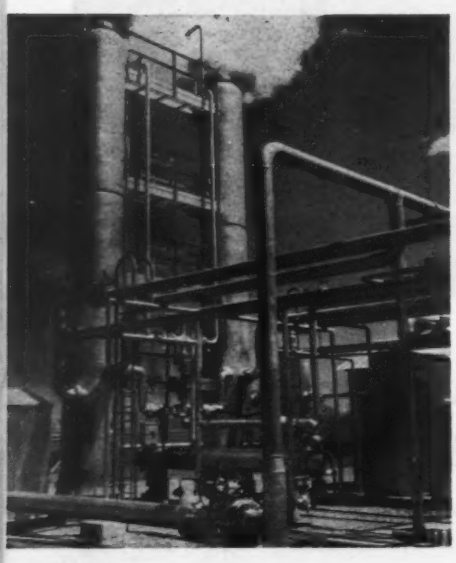
Major Process Improvement Marks 1947 Refining Developments

by Arch L. Foster



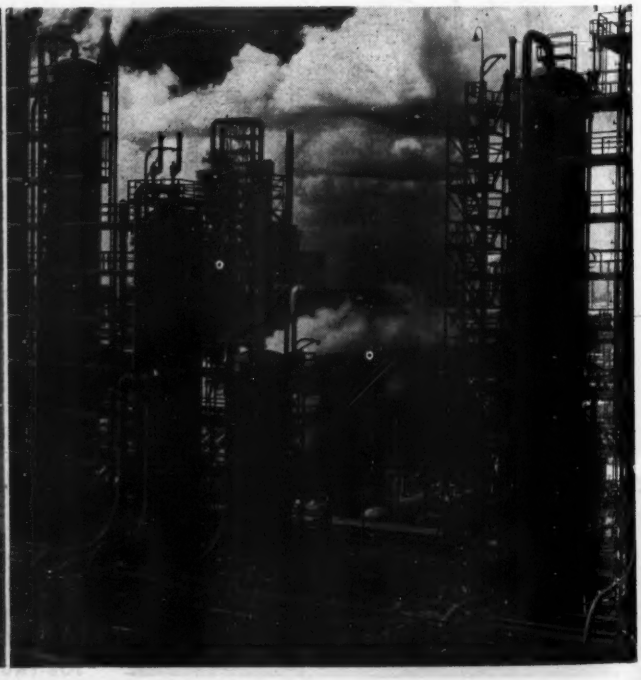
AS 1947 gets under way the refining industry is preparing for the very real battle ahead, the battle for quality and business, for output and octane numbers. This fact is proved by even a hasty glance at the new processes being installed and the new developments which are becoming available to the refiner. Revamping of old units and processes is going hand in hand with the building of the new. War-born discoveries have pushed up some older processes to new efficiency levels; even new processes are showing increased returns in quality and yield of products, to aid and to intensify competition.

The so-called "octane race" has been slowed down and discouraged in some measure, chiefly by two factors: inability to get materials with which to build new units, and the shortage of tetraethyl lead due to insufficient supplies of metallic lead. Both these inadequacies are being corrected as rapidly as possible, yet the pressure for more and more is increasing. Refiners have not gone all-out in gasoline-quality improvement since

Left: The most recent types of units make possible an exactness of processing not possible in earlier operations, as witness these twin dehydrator towers in Skelly Oil Co.'s Kingsmill plant, Texas Panhandle community repressuring operation

Below, left: A typical Thermofor catalytic cracking unit built during the war, now being converted to production of peacetime motor and other fuels, at the Bayonne, N. J., refinery of Tide Water Associated Oil Co.

Below, right: An extremely busy section in the fractionating division of Humble Oil & Refining Co.'s Baytown, Texas, refinery, with a Fluid catalytic unit in the background



trouble for the whole industry may result from injudicious cut-throat competitive practices. Many qualified observers, however, see the approaching end of this partial truce sometime during the current season.

That such an end to the milder forms of competition is expected is evidenced by the number of new units, especially catalytic crackers, polymerization units, and similar processes which have been reported as building or planned for 1947. The most recently obtained returns show that more than 50 major refining units are planned, the earlier of them being already under construction. This figure does not include so-called special plants such as the two units planned or building to apply the Fischer-Tropsch reaction to synthesis of gasoline and other petroleum-type hydrocarbons. Reportedly, these two units, by Carthage Hydrocol, Inc., and the Standard-Kellogg interests respectively, will produce 12,000 bbl. or more per day of synthetic motor fuels and other hydrocarbon and chemical products from natural gas as raw material. The figures on projected new units include a dozen or so catalytic cracking units of different processes. These units will range in capacity from unannounced values up to 25,000 bbl. of charge per day.

Eight or ten catalytic reforming and/or desulfurizing units are under plan, to aid the refiners to meet octane competition at the lowest apparent investment and operating costs. A half dozen or more of thermal cracking or reforming units are planned or building, with several others being rumored or reported by grapevine. At least eight lubricating-oil plants have been reported, either new plants or increases in capacity of existing plants. Several catalytic polymerization units are reported under way, most of them in connection with catalytic crackers which offer certain advantages in charge stock.

New planned catalytic cracking capacity will total more than 100,000 bbl. of charge per day. Old catalytic cracking capacity in existing refineries totals more than 1,050,000 bbl. of daily charge capacity. This value represents the catalytic cracking which is serving a crude charge capacity of approximately 2,900,000 bbl. as a minimum. Most of the new capacity is in smaller refineries; two smaller units, one for the revised Fluid design, and one for the revised Thermofor process were announced sometime ago. New projected catalytic cracking shows more than 100,000 bbl. of daily charging capacity, representing 1,000,000 bbl. of crude capacity. Catalytic reforming is receiving a great deal of favorable attention from medium-to-small-capacity refining companies.

Trends in designs of motor fuels and automotive and similar engines are playing the age-old game of tag. Each one inches forward slightly, development being based primarily on octane ratings of current fuels on one hand, and on antiknock demands of the most "advanced" engines on the other. Development of motor fuels before and during the war disclosed numerous interesting facts. One of these is the difference between the characteristics of thermally cracked and of catalytically cracked fuels and their components. Much of

(Continued on page 243)

Right: This molecular still, developed by Gulf Research & Development Corp. scientists, operates at extremely low pressures and obtains a degree of separation of materials, even solids, that has never been attained heretofore. Dr. John R. Bowman pioneered this development and is shown taking data which an assistant is recording

Below, left: Fluid catalytic cracking unit constructed recently for Standard Oil Co. (Indiana) at Whiting, to make better motor fuels

Below, right: An electrical computer, one of the newer aids to research and making possible mathematical solutions practically otherwise impossible, and extremely time consuming; it is in operation in Universal Oil Products Co.'s laboratory

"Arc Booster" Simplifies AC Welding

Lincoln Electric announces new industrial type AC welder

A NEW heavy-duty transformer type welder, the "Fleet-Arc" has been introduced by The Lincoln Electric Company which improves AC welding by affording greater ease of arc striking, deeper penetration at the start, wider range of output, greater economy of operation and greater safety. It is applicable to a wide range of applications throughout industry.

A feature known as the "Arc Booster" gives the arc a burst of current the instant the electrode touches the work, starting the arc automatically. The current then returns in a fraction of a second to the amount set for the job. A selector switch provides adjustment of the booster current for any degree of arc striking intensity to suit the job.

Improves Penetration at Start

To improve penetration at the start of a bead, the "Arc Booster" of this new welder can be set to dig in with deep penetration. This is especially important for tack welds and short beads.

Improves Arc Characteristics

The welder has a reactor type of control which is a free circuit, designed for high responsiveness to changing arc conditions. It is separate from the main transformer which is designed for high efficiency. This design gives high arc sensitivity for maximum ease and speed of welding under all conditions; it makes possible an exceptionally wide range of output; and it improves power efficiency.

Current Adjustment is Continuous

The rotating reactor control provides step-less, smooth, accurate adjustment of welding current over the entire range of the welder. The operator simply turns a hand wheel. A double reduction chain drive makes it easy to turn the control and requires a minimum number of turns of the handle to cover the range. The amperage is indicated on a dial on the front of the welder.

The reactor current control is held in position by rugged cone brakes, preventing vibration and wear of the control mechanism.

Increases Safety

The open circuit voltage of the "Fleet-Arc" AC welders never exceeds 63 to 70 volts (depending on welder capacity). This eliminates the hazards of the high open circuit voltages which are used in the usual AC welders to improve arc striking.

Reduces Idle Power Consumption

The independent control circuit eliminates the need for high open circuit voltage, contributes to higher power factor. By reducing amount of condensers needed as much as 66%, this new welder minimizes idle power input.

Is Completely Self-Protected

A thermostatic device protects the windings of the welder from damage due to overheating, opening the welder's magnetic starter under such conditions. This feature permits the welder to be used at high current values for sustained periods without danger of burn-out.

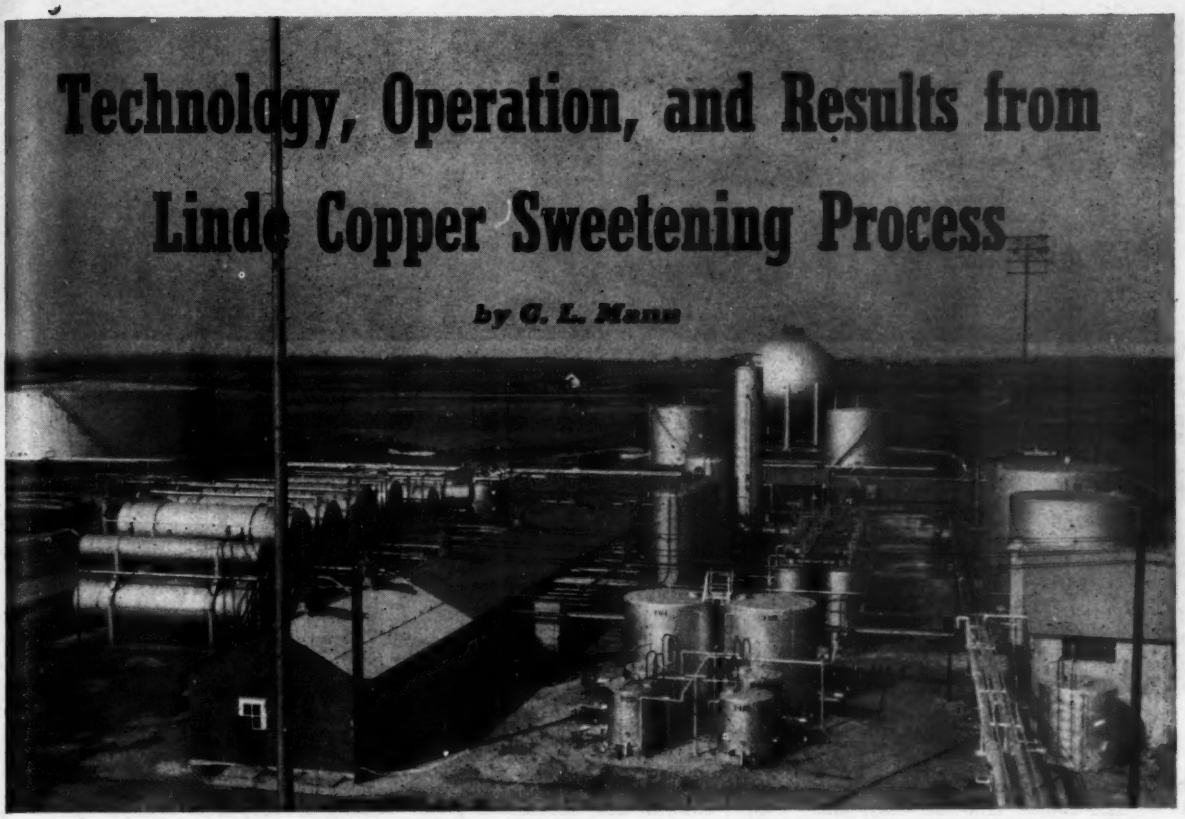
Immediate Delivery

The new welders are available from stock in ratings of 200, 300 and 500 amperes. Complete information on the "Fleet-Arc" AC Welders is given in Bul. 366 which may be had by writing The Lincoln Electric Company, Dept. 203, Cleveland 1, Ohio.

Advertisement

Technology, Operation, and Results from Linde Copper Sweetening Process

by G. L. Mann



Over-all view of Linde copper-sweetening installation at the Socony-Vacuum refinery at Augusta, Kans.

THE Linde copper-sweetening process has been used commercially for many years for sweetening straightrun gasoline, thermally and catalytically cracked gasolines, kerosenes, special solvents, and distillates. The process accomplishes the same final results as the doctor process with many advantages. The organic mercaptans are converted to disulfides by means of the chemical reaction between the organic mercaptans, copper chloride, and oxygen.

The first step in the process is the complete removal of hydrogen sulfide. The sour hydrocarbons are brought in contact with a solution of sodium hydroxide or sodium carbonate in conventional equipment. The sour stock is then passed through a salt filter to remove all mechanically suspended water. It then flows through a heater where the temperature of the hydrocarbons is increased sufficiently to enable the hydrocarbons to dissolve the water formed in the sweetening reaction and thus remove it from the treating tank. This water reaction is directly proportional to the mercaptan content and is readily removed by utilizing the increase in solubility of water in hydrocarbons with increased temperatures. A temperature increase of 5° to 25° F. is usually sufficient for the average stock; occasionally higher temperature differentials are necessary for the higher mercaptan stocks.

The process for oxidizing mercaptans in light distillates to disulfides, etc., by means of copper chloride and molecular oxygen, with subsequent reactivation of the reagent has been in use for several years and shows advantages over the older, widely used doctor sweetening process. Oxygen is added to a copper chloride-clay-water slurry for the purpose of regenerating the chloride reagent continuously. For each 0.01 per cent of mercaptan sulfur in the distillate 0.10 cu. ft. of oxygen is added per barrel of distillate processed. Two methods for removing all traces of copper compounds from the treated hydrocarbons are discussed.

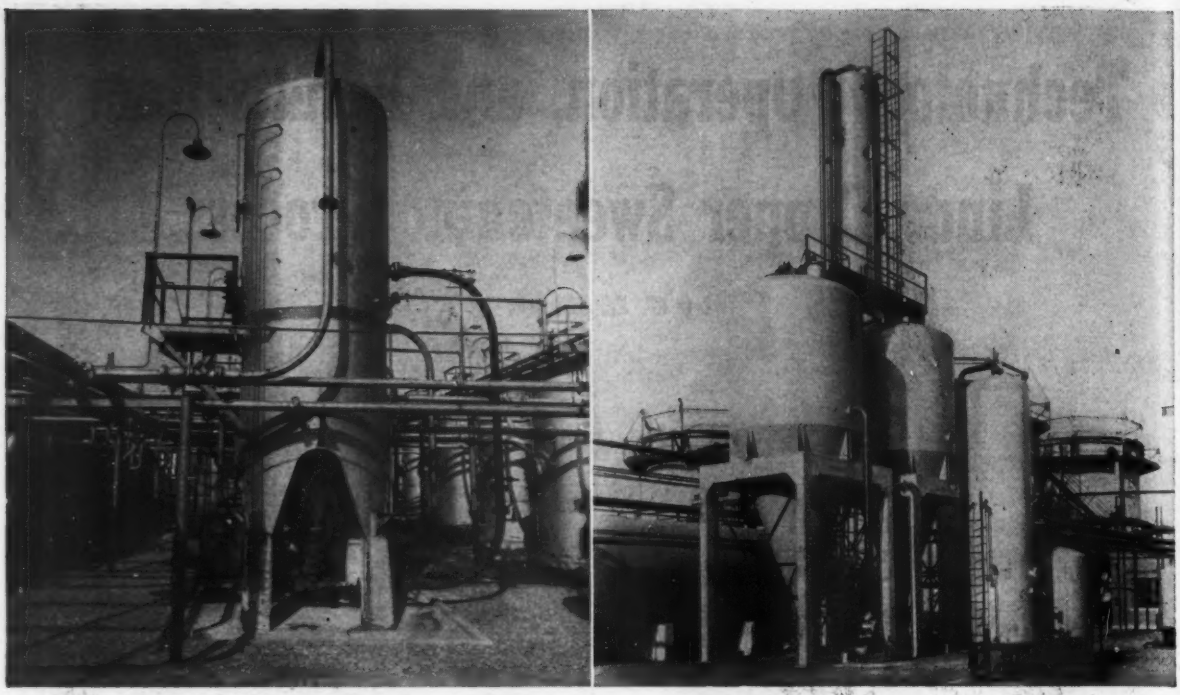
G. L. Mann is a sales engineer with the New York office of The Linde Air Products Co. In 1937, he received his M.S. in chemical engineering from West Virginia University where he was an American Gas Association fellow for 2 years. He has been active in development work with Linde and has devoted a major portion of his time to the oil industry.

Sweetening Procedure

From the heater, the sour hydrocarbons flow to the suction of a centrifugal pump which discharges the stock at approximately 100 psig. About 10 per cent of the total stock flows through an eductor and is reintroduced into the suction side of the pump. Pure oxygen for the regeneration of the copper chloride is constantly added to this bypassed portion of the stock at the suction side of the eductor. In the centrifugal pump the portion of the stock containing the oxygen is intermingled with the main flow and the oxygen becomes uniformly dispersed in the hydrocarbons. The amount of oxygen required is small—approximately 0.10 cu. ft. per barrel for each 0.01 per cent of mercaptan sulfur.

A mixture of 200-mesh clay and 40-60 mesh copper chloride is added to the slurry makeup pot and hydrocarbon stock from the centrifugal pump is introduced to pressurize the pot. This mixture of clay, copper chloride, and hydrocarbons is forced under pressure into the treating tank.

The total throughput of the hydrocarbons containing the dissolved oxygen is discharged from the centrifugal pump through an eductor, the suction side of which is connected to the



Left: Closeup of a slurry tank showing the eductor. Right: The cone-bottom slurry treating tanks of the Cities Service installation

bottom of the cone of the treating tank. The copper chloride, clay, and hydrocarbons flow as a slurry from the bottom of the treating tank into the eductor. Here the slurry contacts intimately the oxygen and sour hydrocarbons and the chemicals which results in immediate sweetening of the hydrocarbons. This efficient method of contacting results in the rapid regeneration of the copper chloride, maintains chemical costs at a minimum, and enhances the quality of the finished product. Thus the eductor is an important element in this sweetening process.

The mixture of slurry and sweetened stock flows through a return line into the reactor vessel. Here the copper chloride-clay mixture is given initial downward velocity and settles into the conical bottom to be reused. The sweet stock flows upward and is discharged from the top.

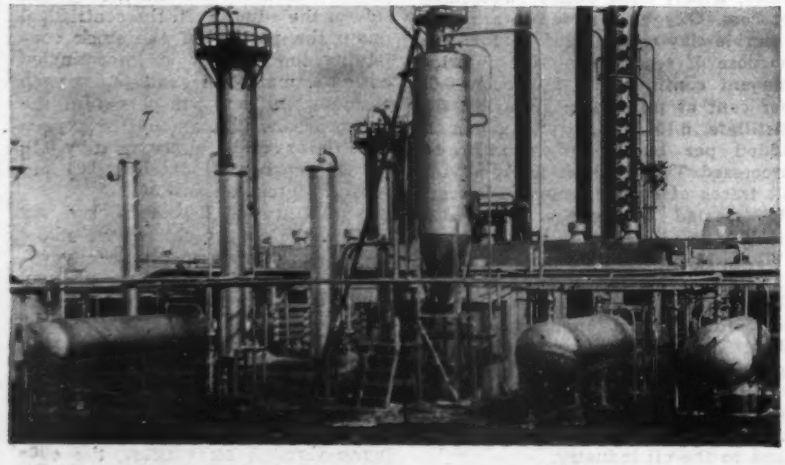
The stock from the top of the treating tank flows through a mixing device where it is contacted with water, the water-stock mixture discharges into a settling tank, and the water settles and is recirculated. In installations where fresh water is added continuously, the amount of fresh water required ranges from 5 per cent to 25 per cent of the stock throughput. In installations where fresh water is added in batches, the water in the wash vessel is usually changed every 1 to 3 days.

If straightrun gasoline is being treated it may be passed from the top of the water tank directly to field storage or through a salt tank to remove entrained water. The use of this latter procedure is left to the discretion of the refiner.

A vigorous water wash is generally effective in removing all but minute quantities of copper compounds from cracked gasoline. The cracked gasoline should then be given an additional treatment to either remove these minute quantities of copper compounds or deactivate the copper compounds. Either one of two treatments may be used, depending upon local conditions.

One method of removing copper compounds is to contact the gasoline with alkaline sodium sulfide solution. This is done in the same manner as the original sodium hydroxide wash or the water wash. If inhibitors are to be added to the gasoline, the sodium sulfide treatment should be followed with a water wash or the gasoline percolated through a salt bed. The water wash or the salt bed will remove traces of alkaline sodium sulfide which may be carried over from the sodium sulfide treatment. Small amounts of alkali in gasoline impair the effectiveness of inhibitors.

An alternate method for treating gasoline containing dissolved copper compounds in hydrocarbons is the addition of a metal deactivator. Immediately following the final salt filter, small quantities of a suitable



Linde copper-sweetening unit at Cooperative Refinery Association, Phillipsburg, Kans.

The cascade oxygen storage unit at Augusta is typical of the oxygen-supply facilities usually used for large Linde copper-sweetening units

copper deactivator should be added to the stock. The deactivator may be added along with inhibitor if the end product is being inhibited.

Both these methods of treatment for dissolved copper compounds are satisfactory. The relative costs of the two methods would be the deciding factor in the selection of the type of treatment.

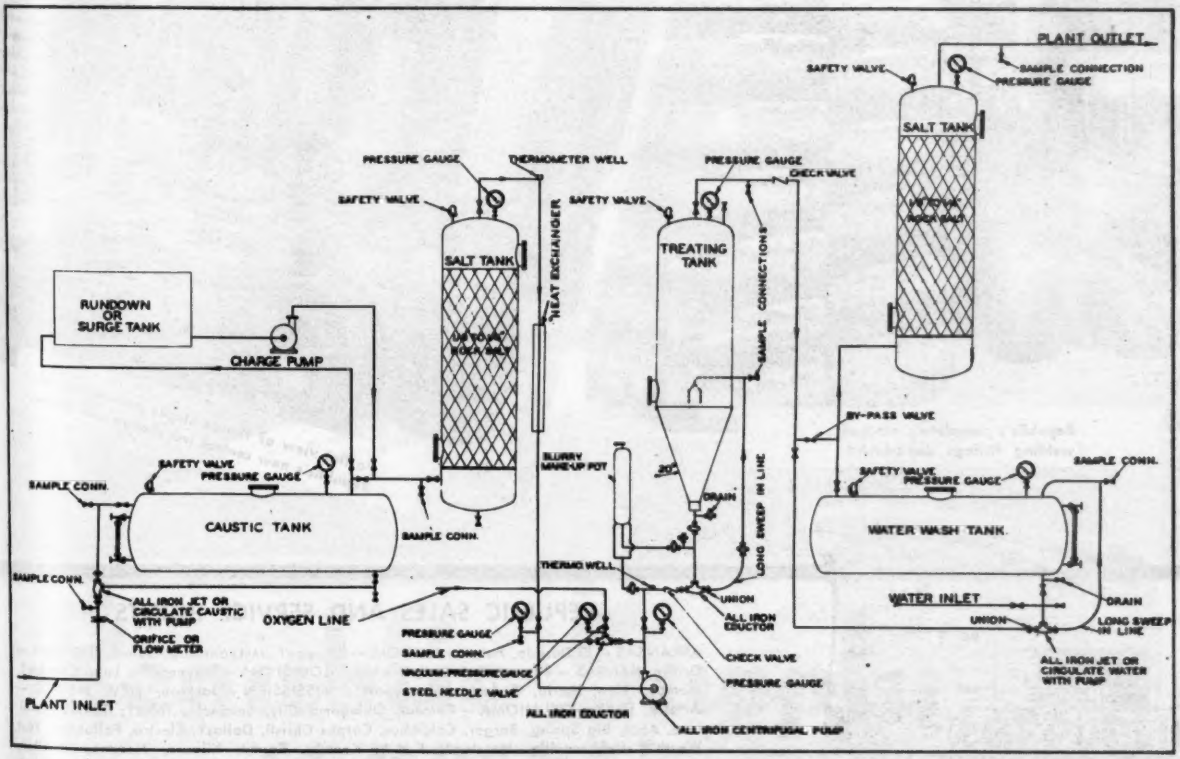
Typical Installations

A number of Linde copper-sweetening units have now been in service as long as 8 years and are giving excellent results with a low operating cost. Major savings have been effected and the original investment cost has been paid off in less than a year.

One of the first installations was in the Socony-Vacuum Oil Co., Inc., refinery at Augusta, Kans. This refinery has a total of six sweetening units with a combined capacity of 25,000 bbl. per day of cracked and straight-run gasolines, recovery gasoline, kerosene, and heating fuel. Several of the illustrations show details of this installation.

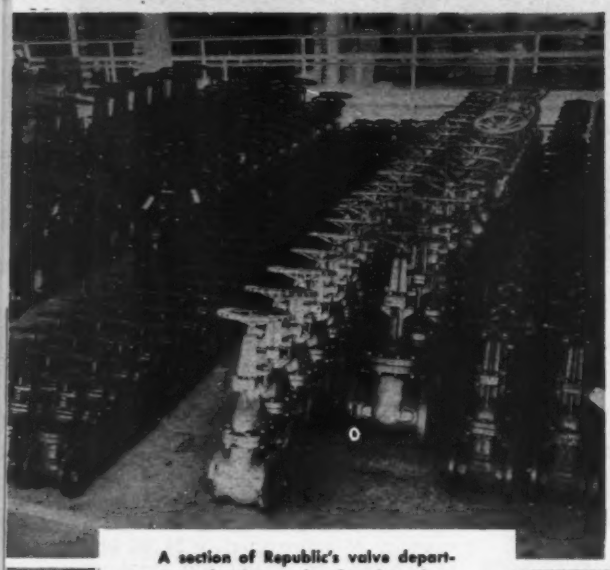
A typical Linde copper-sweetening installation in a small refinery is that of the Cooperative Refinery Association at Phillipsburg, Kans. This sweetening unit has a capacity of 1,200 bbl. of cracked gasoline per day. Standard tanks are used for the horizontal precaustic and afterwash vessels. The vertical salt filters were made from large-diameter pipe. The treating tank with conical bottom is a conventional vessel, converted over to the specific needs of this particular unit.

The installation at the Cities Service Oil Co. refinery at East Chicago, Ind., is typical of practices in a larger refinery. This sweetening unit has a capacity of approximately 24,000 bbl. of cracked and straightrun gasolines per day. The two treating tanks are connected in parallel, and each treating tank can handle approximately 500 bbl. per hour. The treating tanks are 12 ft. in diameter and 28 ft. in over-all height. The vessels were readily fabricated from standard steel plate.



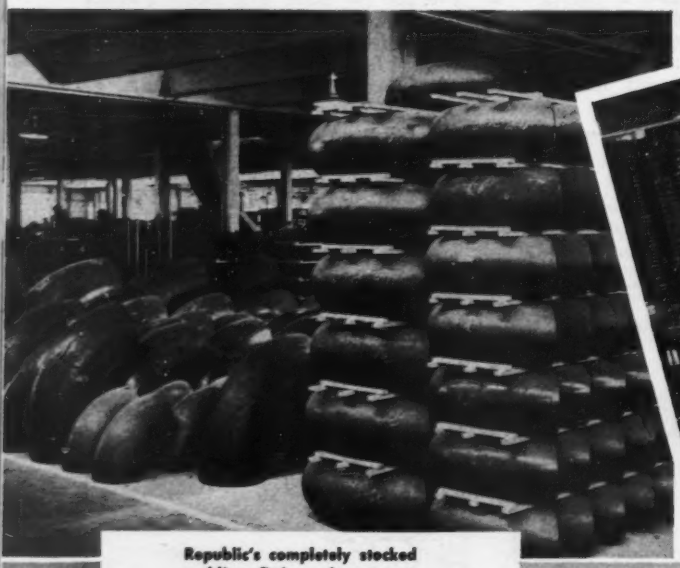
Flow chart of Linde copper-sweetening process showing arrangement of caustic, treating, and salt tanks

MODERN REFINER



A section of Republic's valve department showing stocks of various sizes.

Plug valve stocks at Republic's new central warehouse and store in Houston.



Republic's completely stocked welding fittings department.

Partial view of flange stocks maintained at Republic's new central warehouse and store.

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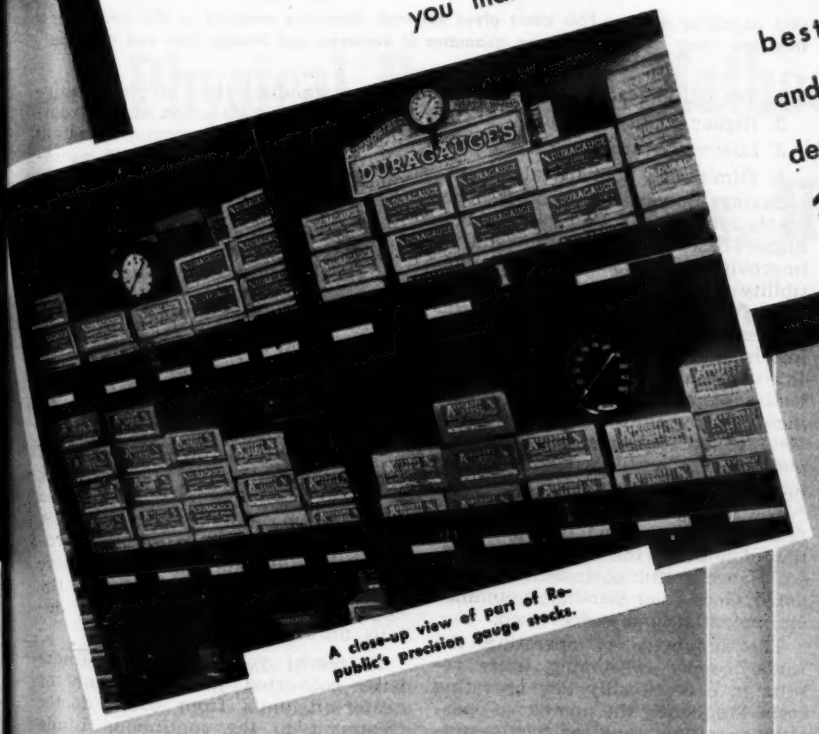

A close-up view of part of Republic's precision gauge stocks.

Republic Supply COMPANY

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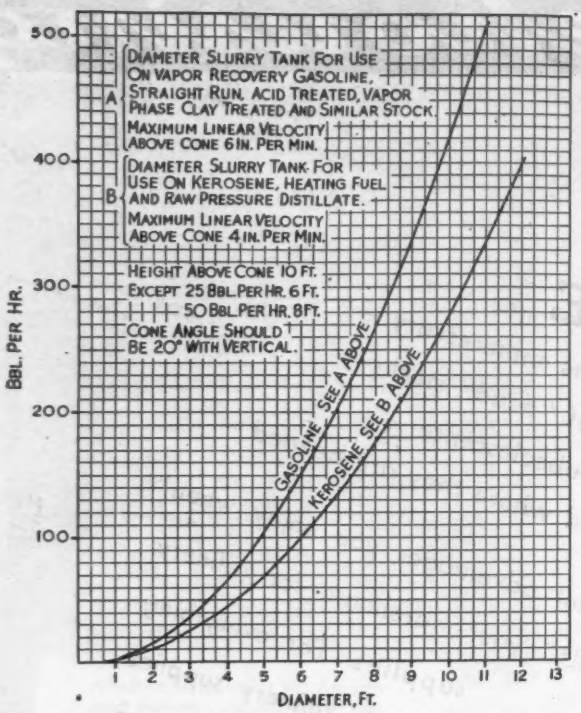
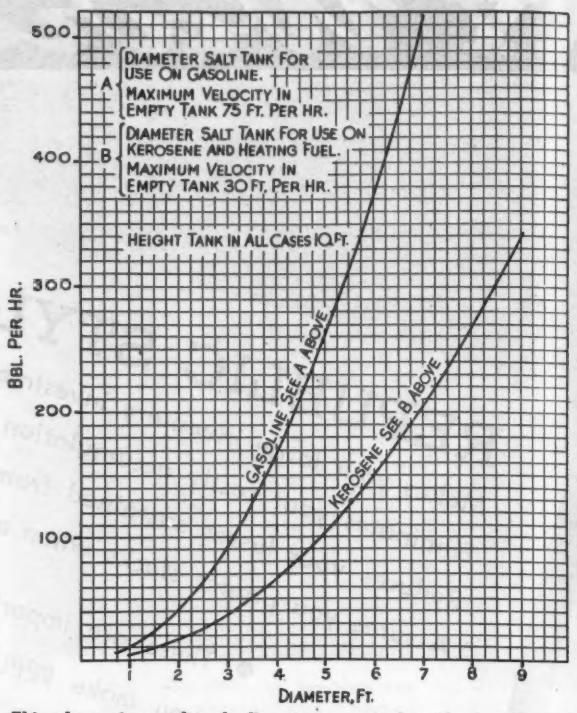

DIAMETER SLURRY TANK FOR USE ON VAPOR RECOVERY GASOLINE, STRAIGHT RUN, ACID TREATED, VAPOR PHASE CLAY TREATED AND SIMILAR STOCK.
A
MAXIMUM LINEAR VELOCITY ABOVE CONE 6 IN. PER MIN.
DIAMETER SLURRY TANK FOR USE ON KEROSENE, HEATING FUEL AND RAW PRESSURE DISTILLATE.
B
MAXIMUM LINEAR VELOCITY ABOVE CONE 4 IN. PER MIN.
HEIGHT ABOVE CONE 10 FT. EXCEPT 25 BBL. PER HR. 6 FT. 50 BBL. PER HR. 8 FT.
CONE ANGLE SHOULD BE 20° WITH VERTICAL.
GASOLINE SEE A ABOVE
KEROSENE SEE B ABOVE
BBL. PER HR.
DIAMETER, FT.

Slurry-tank diameters for treating units of varying capacities and for various products may be determined from this chart


DIAMETER SALT TANK FOR USE ON GASOLINE.
A
MAXIMUM VELOCITY IN EMPTY TANK 75 FT. PER HR.
DIAMETER SALT TANK FOR USE ON KEROSENE AND HEATING FUEL.
B
MAXIMUM VELOCITY IN EMPTY TANK 30 FT. PER HR.
HEIGHT TANK IN ALL CASES 10 FT.
GASOLINE SEE A ABOVE
KEROSENE SEE B ABOVE
BBL. PER HR.
DIAMETER, FT.

This chart gives salt-tank diameters required in the treatment of varying quantities of kerosene and heating fuel and gasoline

Many installations have been made by converting doctor plants to the Linde copper-sweetening process. The contact and settling vessels that normally were used in the doctor plant have been converted into wash vessels and treating tanks for the Linde process. Often a horizontal settling vessel has been fitted with a conical bottom and used in the vertical position as a treating tank.

The oxygen consumption depends on the quantity of hydrocarbon treated and the mercaptan sulfur content of the hydrocarbon. If the demand does not exceed about 50 cu. ft. per hour, oxygen is usually supplied from manifolded cylinders. This should be a dual manifold installation to assure a continuous flow of oxygen.

Usually oxygen flows in excess of 50 cu. ft. per hour are best supplied by a large-capacity unit such as a Cascade oxygen storage unit. The Cascade unit consists of a number of permanently installed special large tubes for storing gaseous oxygen. The oxygen is delivered in liquid form in special tank trucks which include equipment for converting the liquid to gaseous oxygen and discharging it into the storage unit. From the storage unit the oxygen flows by pipe line to the sweetening unit. This method of supplying oxygen eliminates the time and expense involved in handling cylinders.

Advantages of the Process

The advantages of the Linde copper-sweetening process are:

1. Tetraethyl lead savings.
2. Higher quality products.
3. Lower operating costs.
4. Elimination of material losses.

Savings in tetraethyl lead requirements are effected by maintaining a higher base octane gasoline and by improving the tetraethyl lead susceptibility of the gasoline. As there is no loss of volatile light fractions in this process due to evaporation, the original base octane number of the gasoline is maintained. The tetraethyl lead susceptibility of the gasoline is increased by elimination of the objectionable sulfur compounds (alkyl polysulfides) resulting from the doctor process.

The higher quality product results directly from the fact that the addition of sulfur in the treating is avoided. Hence sulfur corrosion is eliminated. Good color stability is obtained and potential gum is decreased.

The simplicity of operating the Linde copper-sweetening units results in exceptionally low operating costs. Frequently the number of operating personnel required by the previous treating process can be reduced. The initial investment cost is low as vessels or other equipment usually on hand at the refinery can be used in constructing the unit. The sizes of tanks required are indicated in the graphs. An existing treating plant can often be readily converted to a Linde copper sweetening at small capital outlay. The use of dry copper chloride eliminates the possibility of corrosive action and makes it possible to use standard steel or iron equipment in the construction of the treating unit. Special corrosion-resistant alloys are not necessary, and consequently fabricating costs are low.

In the Linde ccopper-sweetening process losses due to the formation of sludges are eliminated. The closed system eliminates evaporation losses.

Current Status of Process

The extent of the application of the Linde copper-sweetening process is reflected in the yearly increase in the volume and type of stock treated. These Linde units are now operating in most of the oil refining centers of the United States and are processing a wide assortment of straightrun gasolines, thermally cracked gasolines, catalytically cracked gasolines, kerosenes, solvents, and distillates. There have been no major changes in the engineering design or operating details during these years.

In recent years, several refiners have converted their kerosene or heater-oil units from batch doctor treatment to the continuous Linde copper-sweetening process. This changeover has reduced treating cost and material loss. It has eliminated the troublesome sludges and long delays in regeneration, and has improved the burning characteristics of these distillates. Burner tests are found to be excellent, with assured negative copper strip corrosion test.

The Linde copper-sweetening process is licensed by The Linde Air Products Co., New York.

J. B. Grutka operating the mass spectrometer installed in U.O.P. Riverside laboratories

Physical Research Methods Increase Knowledge of Catalysts, Hydrocarbons

by Dr. Glenn M. Webb

A NEW technology is being built up for the oil industry to give the refiner more knowledge of the crude he processes, by means of physical methods new to science. These methods include the electron microscope; X-ray and electron diffraction; infrared, ultraviolet, and Raman spectroscopy, mass spectrometry, etc. Much attention is being given by these methods to catalysis and catalysts, and other material and many reactions in petroleum technology. The radiation cycles used vary extremely low values of one cycle in hundreds of years to 10,000 million cubed cycles per second.

IN their ceaseless search for more knowledge about the composition, characteristics, and useful possibilities of hydrocarbons, catalysts, and other substances that enter into refining operations, petroleum technologists have sought the aid of various physical-research techniques and instruments which are valuable supplements to the familiar chemical tools of investigation that have been developed and used in the refining industry for many years.

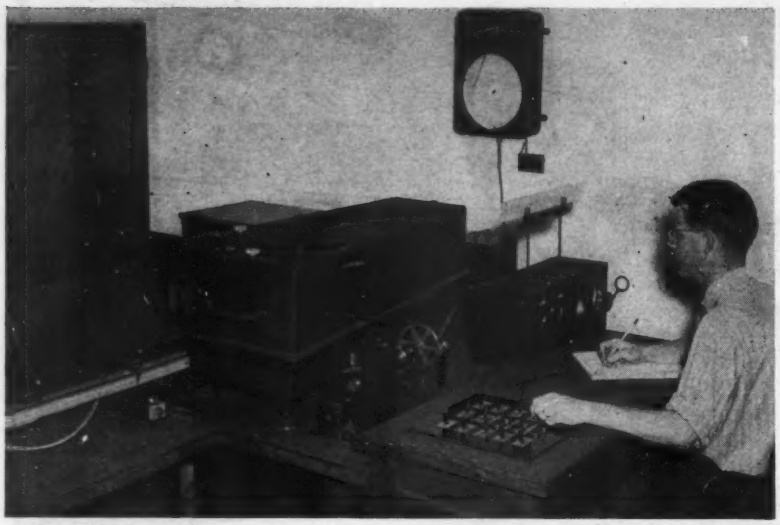
These methods, many of which are in daily use in Universal research laboratories, tap new sources of knowledge about petroleum, catalysts, and other materials used in the petroleum industry. Hitherto unknown facts of far-reaching significance have been discovered. A body of technology new to the oil industry is being built up, with the result that the refiner today can obtain more information about the nature of the crude he runs, and the most profitable methods of refining it, than was ever available before. Data derived from these physical methods are being applied directly to the solution of a great variety of problems which refiners encounter in their everyday operations.

Included among these techniques are: X-ray diffraction and electron diffraction; surface-area measuring equipment; infrared, ultraviolet, and Raman spectroscopy; mass spectrometry, and a wide variety of physical and electrical apparatus for determining various properties of oils and catalysts, such as dielectric constants, porosities, freezing points, and so on.

X-ray diffraction, electron diffraction, and surface-area measuring equipment have been and are being successfully used for the study and improvement of catalysts. Infrared, ultraviolet, and Raman spectroscopy and mass spectrometry are employed for the identification and study of hydrocarbon liquids and gases, some of which have constituents that cannot be detected by any other means.

These modern techniques do not supersede nor invalidate the time-honored distillation, viscosity, gravity, pour test, and other physical and chemical tests which for so long have been standard in the refining industry, but their range of usefulness goes far beyond that of the older methods.

Before considering the respective functions of these various techniques, and the principles upon which they are based, a word about catalysts is



Dr. W. S. Galloway studying the absorption spectrum of triptane on the infrared spectrometer

THE AUTHOR

Dr. G. M. Webb, physics division, Universal Oil Products Co., graduated from California Institute of Technology in 1931 with the B.S. degree in physics and mathematics. Postgraduate work in the same subjects in Washington University, St. Louis, as successively laboratory assistant, teaching fellow and research fellow, earned the M. S. degree in 1933 and the Ph.D. in 1935. From 1935 to 1937 Dr. Webb was employed by Western Cartridge Co., East Alton, Ill., joining Universal in 1937. For a year and a half during the war, Dr. Webb, in addition to his work at Universal, was a consultant on catalysts in the Manhattan project.

He is a member of American Physical Society, Physics Club of Chicago, Electron Microscope Society of America, Division of Electron and Ion Optics of A.P.I., American Chemical Society and Association of New York Scientists.

pertinent. The growing magnitude of the part played by catalysis in the refining industry is well known. The further study and improvement of catalysts, therefore, is of prime importance.

The first widespread commercial use of catalysis in the refining industry was in the polymerization of light refinery gases over a solid phosphoric acid catalyst to produce a liquid fuel of about 81-octane rating. The light gases so used were formerly considered waste gases and burned as refinery fuel; but when converted into polymer gasoline they increase the net motor fuel in yield in thermal cracking by 3-5 per cent and raise the octane rating by about two points.

With this achievement behind them, the researchers proceeded in a systematic and empirical manner to apply the art of catalysis to the other branches of refining, with results of inestimable importance.

Aviation Fuel Custom-Built

The millions of barrels of aviation gasoline produced during the war were almost entirely custom built by use of a group of catalytic processes with catalytic cracking playing the leading role and catalytic polymerization, alkylation, isomerization, hydrogenation, and dehydrogenation having important parts.

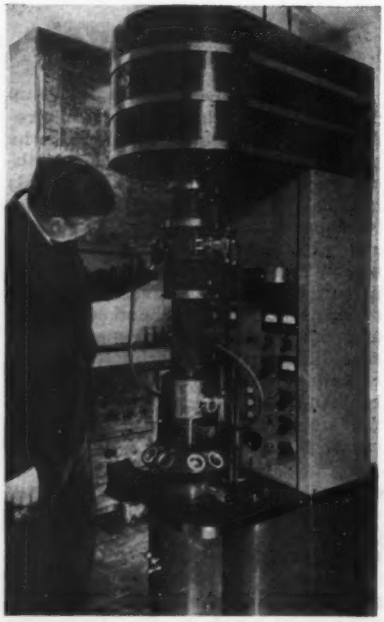
Large quantities of synthetic toluene, and other aromatics, were made from petroleum by catalytic methods. The chief components of buna-S rubber, styrene, and butadiene, result from applying catalytic techniques to petroleum fractions.

These brief remarks will suffice to recall the tremendous importance of catalysis to the present-day refiner, both from the technical and economical points of view, as well as to indicate the great strides which the art has made. This is in marked contrast to the slow progress that has been made in our understanding of the fundamental behavior of catalysts. It is still usually necessary to make hundreds of tests to find, by empirical methods, a catalyst that has desirable and usable characteristics.

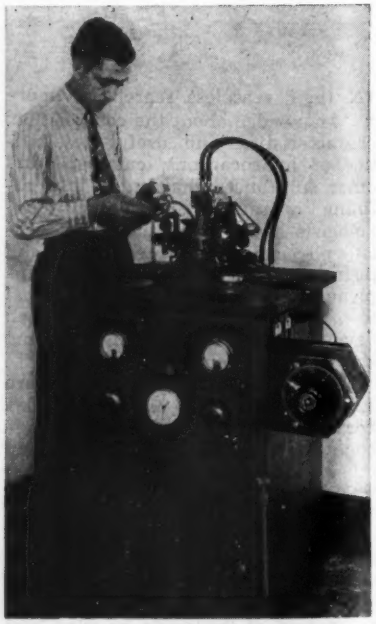
The proper application of physical research techniques can confidently be expected to put the phenomenon of catalysis on a scientific basis, so that predictions may be made with respect to both the discovery of new catalysts and the improvement of existing ones.

The main purpose of this paper is to consider the ways in which these physical-research methods may be used to solve more readily the problems encountered in petroleum-chemical technology.

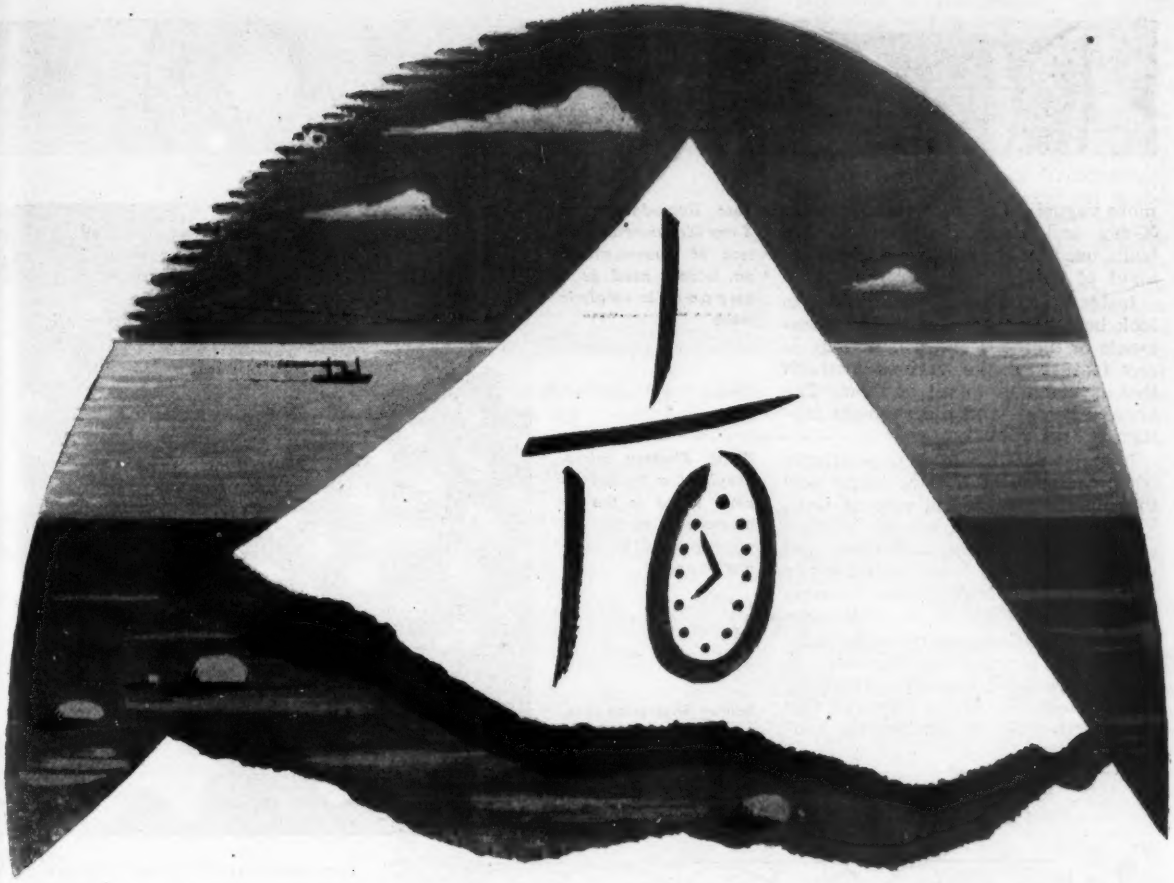
One way of doing this would be merely to list the different tools and techniques physicists use, and to illustrate their application by reference to specific cases. However, this would likely be dull and not very instructive, for it is well known that spectrographs of various types are daily being used to control chemical processing plants, and it is also well realized, although perhaps somewhat



Dr. C. H. Ehrhardt introducing a specimen into the electron microscope



L. W. Schiefelbein mounting small camera for powder-diffraction work on X-ray diffraction unit



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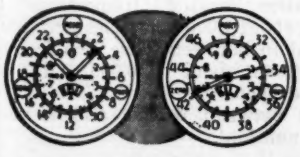

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more vaguely, that such techniques as X-ray and electron diffraction are being used for the study and improvement of catalysts.

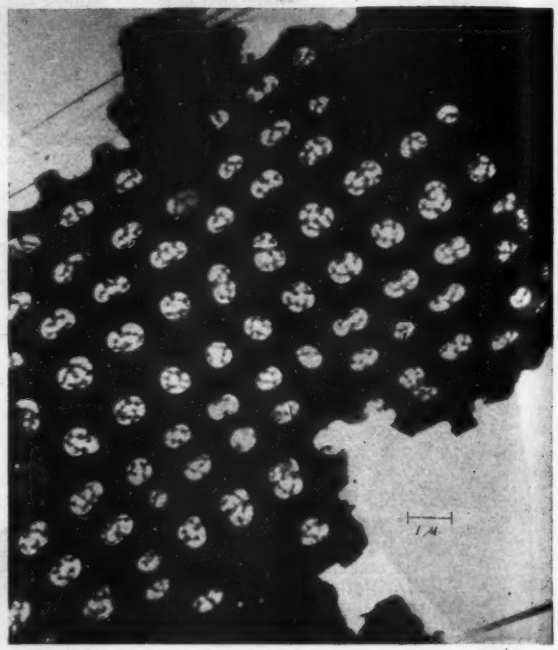
Instead, it is more profitable to look beyond any one of these instruments or methods and ask if there is any feature of the various methods that is common to all of them. The answer is yes—and the common feature is "radiation."

It is not possible to state positively what radiation is, but we know how to generate radiation of various sorts. We know something of the interactions between these radiations and matter, and we have developed a great many devices to detect or measure the magnitude of the radiations.

These radiations are the very heart of modern physics and they are so closely associated with everything we know about the entire universe that it is worth while to consider the subject briefly.

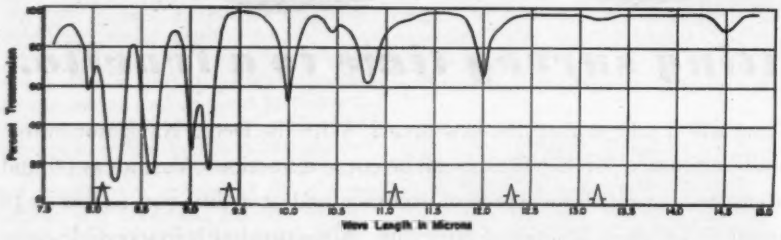
The radiations that are encountered in light, X-rays, and gamma rays, are so-called electromagnetic radiations. These radiations are pulsating, traveling through empty space with the velocity of light. The rate of pulsation, or frequency of the radiation, is defined as the ratio of its velocity, which is the speed of light, to the wave length.

Top: Reproduction of X-ray film showing pattern of gamma-alumina, widely used as a support in catalytic work



Right: Electron micrograph of a typical diatom found in the diatomaceous earths, frequently used as catalyst supports

Below: Absorption spectrum of triptane. The useful portion of this spectrum for analytical purposes is in the region of 8-11 microns



The frequency range, or frequency spectrum, of electromagnetic radiation is very wide; it ranges all the way from the slow variations in the magnetic field of the earth caused by the sun spots, through the 60-cycle/second electric power we use in our lights, and so on through radio, television, visible light, X-rays, and cosmic rays.

This covers a period in time from one cycle every 30,000,000 years to a frequency of 10^{23}, or 10,000 million cubed cycles in 1 second.

There are other frequency spectra that we encounter in every-day life. One is the kinetic spectrum of mechanical and thermal vibrations. This includes the motion of the heavenly bodies in their orbits, the daily cycles of our earth, the cycles of the tides, the oscillation of the pendulum of our mantel clock, the whole range of sound vibrations, thermal agitation of the molecules in a gas, and so on up to the motion and vibration of electrons.

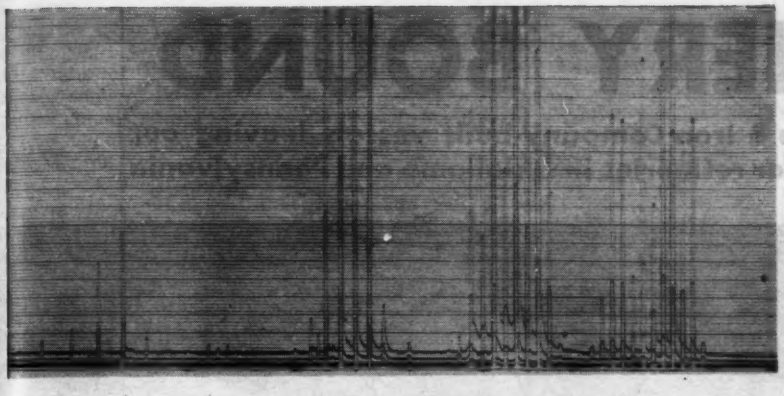
Another spectrum, which may not be so common to some of us, covers the de Broglie matter waves; these are waves which are associated with all matter, and are important only for particles of low mass, such as electrons, protons, neutrons, etc. It is due to the existence of these matter waves, or de Broglie waves as they are called, in honor of the man who first postulated them, that we are able to build electron diffraction apparatuses and electron microscopes with the assurance that the electrons will behave both as material particles and as waves with a definite wave length.

This short review of frequency spectra covers the point we want to make —namely, that most of the things we encounter in every-day life are cyclic in nature and all we do in applying physics to the solution of chemical problems is to make use of these periodic phenomena.

Let us return now to the electromagnetic frequency spectrum and consider its makeup in somewhat more detail. As we saw before, this spectrum covers a very broad range, from about 10^{-7} to 23^{+23} cycles per second. (See Fig. 1). The portion of the spectrum useful at the present time in industrial research work is much smaller than this. For example, at the high-frequency end of the scale neither cosmic rays nor gamma rays, nor even very hard X-rays have yet been used to any great extent as research tools. Likewise, not much practical research use is made of the radiation having frequencies less than about 1,000,000 cycles per second.

But in between these two frequencies, from about 1,000,000 to 1,000,000 cubed cycles per second, the interactions between matter and radiation are manifold.

Let's start at the lower end of this range, at frequencies of about 1,000,000 to 100,000,000 cycles per second. To orient ourselves, we can recall that this is at the upper end of the frequency band used in commercial radio broadcasting. The generation of 10,000,000 cycles per second radiation is accomplished by the use of vacuum-tube oscillators. When this type of



Typical mass spectrum of a C_4 fraction from the overhead of a debutanizer tower fractionating the product from a catalytic cracking unit

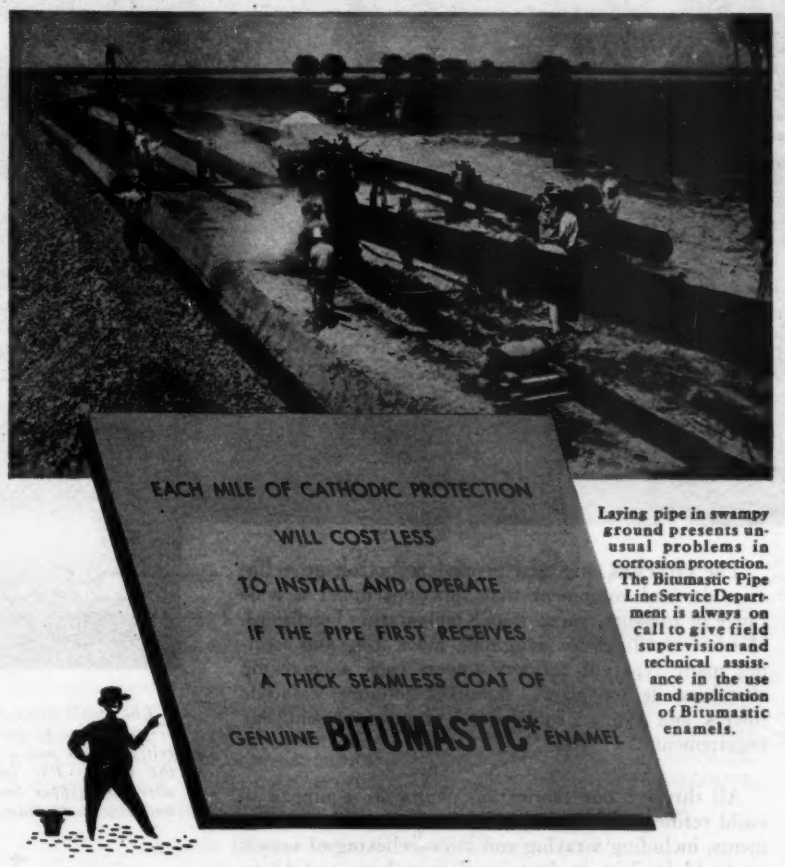
radiation falls on conductors, such as steel tubes, very large high-frequency currents are induced in the surface layers of the metal, giving rise to surface heating. On the other hand, if this same radiation is allowed to fall on a nonconductor, or insulator, the entire volume of the material will be heated. This is primarily due to the oscillation of the molecules of the substance back and forth, as the direction of the radiation changes. The extent or rate of heating is greatly dependent on the particular material being studied; for example, polystyrene when absolutely pure, heats up hardly at all, but if it contains even a trace of impurity, it heats quite readily.

This radiation is also the one that home-equipment manufacturers have publicized so much for home cooking and the like. Radiation of this frequency is also used in medical diathermy, its function being to heat selectively the fatty portions of the parts exposed. For more technical purposes, development of exceedingly pure polystyrene, with its naturally low dielectric constant, was of urgent importance during the war, since it was needed for insulation on various types of high-frequency devices.

Going up the frequency scale to about 10^{15} cycles per second, we come to the radiation known familiarly as visible light. On the low-frequency side of the visible region is the infrared spectrum, and on the high side the ultraviolet. This entire spectral range has been used extensively in investigations in petroleum chemistry.

Infrared, visible, and ultraviolet radiations have long been used for studying organic and inorganic compounds. Molecules may absorb discrete amounts of energy in the form of heat or light by suffering changes in the electronic, rotational, or vibrational energy. Molecules may be simply thought of as consisting of atoms which are held together by linkages between them. Water may be taken as a simple case. Imagine that the hydrogen-oxygen bonds are stretched or compressed; the atoms will then vibrate with a certain frequency which depends on the masses of the elements involved and the strength of the binding forces.

Now quantum mechanics says, among other things, that an infrared absorption band should be observed at the frequency (or frequencies) with which such a mechanical model vibrates. Hence we can see that absorption by a molecule of infrared radiation is accompanied by a change in, for example, the vibration of the skeleton of the molecule. Absorption spectra appearing in the visible and ultraviolet region are due to changes in the electronic configuration of the molecule. These spectra are connected chiefly with the outer electrons which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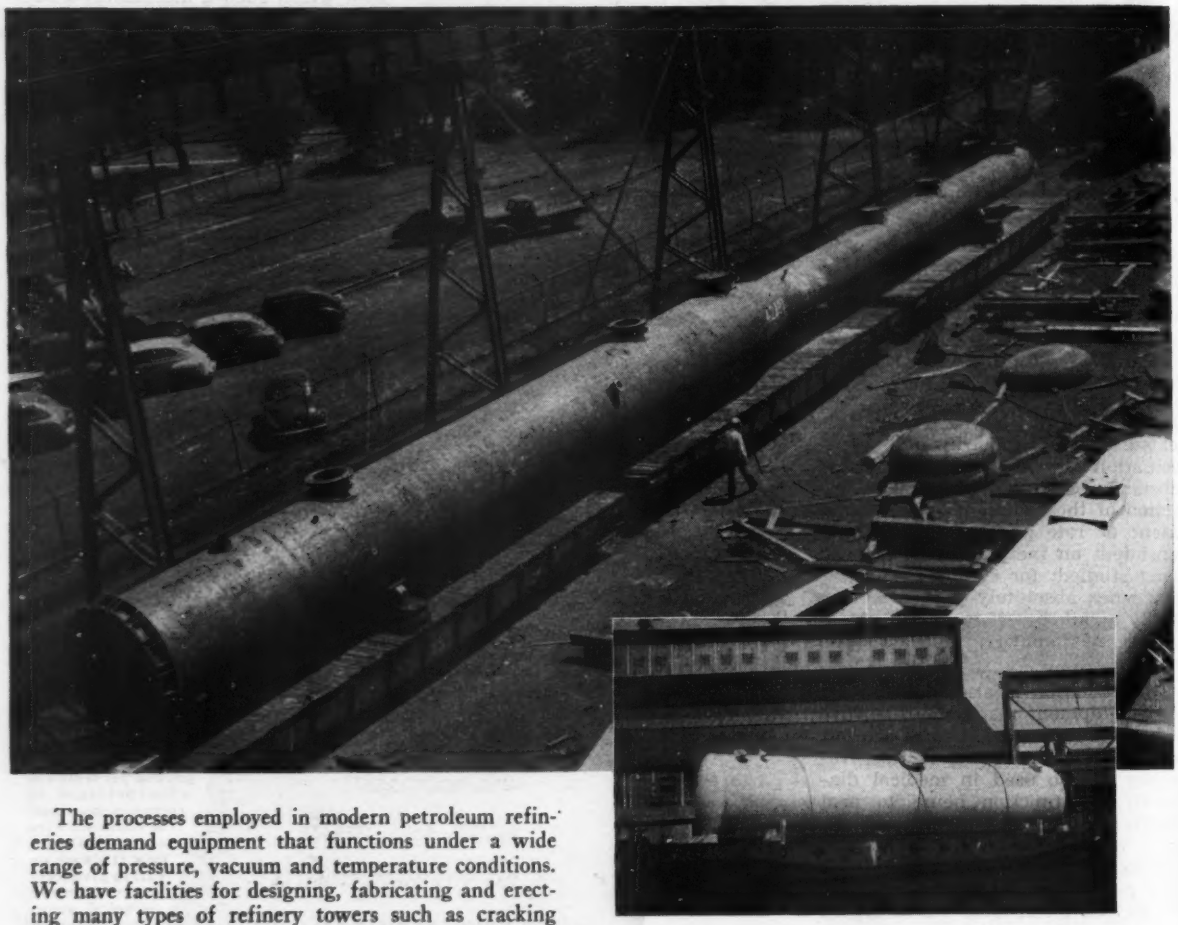

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The small view directly above shows a 7-ft. diam. by 37-ft. 4½-in. pressure vessel. It was x-rayed and stress-relieved and has a special lining welded on one half of the inside. The large view above shows a 140½-ft. absorber-stripper tower. It is 7 ft. in diam. at the bottom and 4½ ft. in diam. at the top.

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are for the most part responsible for the linkages between atoms.

The uses of these phenomena in atacking some of the problems in petroleum chemistry are obvious. Since no two compounds have molecular arrangements that are identical, it follows that the so-called modes of vibration are also different; this being the case, the infrared absorption spectra will be unique for each molecule. A similar situation exists for ultraviolet and visible spectra: The spectrum of each compound is unique; no other compound has exactly the same spectrum.

What do we actually do with these spectra once we have gone to the trouble of getting them? Probably the most striking thing, from the economic point of view, is that analyses of certain types of hydrocarbon mixtures can now be made in a matter of hours where formerly they required days and sometimes weeks.

One example of this type of thing that comes to mind is the determination of the composition of the alkylate blended into our wartime aviation gasoline. In making the infrared analysis, the alkylate is crudely distilled into a few cuts and the infrared absorption spectrum of each cut is then obtained. From previous calibration runs, the composition of each cut is calculated, and from this information the composition of the entire alkylate is finally figured.

High-Speed Analyses

Compare this with a typical analysis made by the conventional method. This method requires that the sample be very carefully and precisely fractionated into about 50 cuts, each of which is tested for index of refraction, boiling point, and perhaps density. The final result is obtained after several days of continuous labor compared to a few hours for the infrared method. In experienced hands, this laborious method yields good results, but unless great care is taken, compounds that comprise an appreciable part of the entire sample may not even be found.

For example, one analysis of the hexane cut from straightrun gasoline has come to our attention, which showed that the sample contained only a trace of the compound, 3-methyl pentane. This analysis was made by a combination of solvent extractions and distillations, and then obtaining boiling points and refractive indices on the cuts. Our own infrared analysis of a similar hexane fraction showed it to contain about 15 per cent of 3-methyl pentane.

There are other less striking, but fundamentally more important, applications made of these spectra. The uses we have in mind are those in which these techniques are employed in directing the course of specific research programs.

As an example of this may be cited some of the work done in connection with the production of alkylate for blending into aviation gasoline. Alkylate made with hydrogen fluoride as catalyst contains a relatively small number of compounds, the predominant ones being the 2,2,4; 2,2,3; 2,3,4, and 2,3,3 trimethyl pentanes, and the 2,3, 2,4, and 2,5 dimethyl hexanes. It is relatively easy to determine the amounts of these compounds in an alkylate by infrared absorption methods. This then provides an accurate way of determining the effects of process variables and feed stocks on the quality of the resulting alkylate.

We will now leave this portion of the electromagnetic frequency spectrum and go to a region of still higher frequencies—up to about 1,000,000 cubed cycles per second. This is where we find X-rays or X-radiation, and it is also the place where the matter waves associated with electrons used in electron diffraction work and in the electron microscope are found.

X-rays are probably more familiar to most of us than even the infrared and ultraviolet radiations. They have now advanced to the ripe age of 50 years, having been discovered in 1895. They are generated by permitting a rapidly moving stream of electrons

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to strike a metal target, the interaction between the electrons and atoms of the metal target resulting in the emission of the X-rays.

Most of us encounter X-rays in the doctor's office or in the dentist's chair for the reason that the X-rays are absorbed to different extents by different materials. Thus, a shadow picture, or silhouette, of a tooth embedded in the gum, can be obtained by irradiating the tooth area with X-rays owing to the fact that the dense tooth absorbs more of the radiation than does the less dense gum. Similarly, X-radiographs are obtained of thick steel plates to reveal the presence of air pockets and the like. These are applications of the great penetrating power of X-rays; but there are many other things that can be done with X-rays besides taking shadow pictures.

The X-radiation is of great interest to us because it has associated with it a wave length of the same order of magnitude as the distance between the atoms of crystals. It was postulated some years ago that by virtue of this fact crystalline substances should behave toward the X-rays in much the same fashion as a lined grating acts on visible light. Experiment showed that this was the case.

As a result of these discoveries, a vast amount of work has been done cataloging the X-ray diffraction patterns of a great many thousands of crystalline materials. A similar situation exists in the case of electron diffraction; here, however, the original postulate involved the assertion that electrons de behave as if they were waves. Calculation showed again that the electrons should be reflected by crystalline substances in much the same way as are X-rays, and experiment confirmed this, too. There is one important distinction, however, between X-rays and electrons: the X-rays are penetrating, and pass through the entire substance on which they are allowed to impinge, only a small portion being reflected to give the diffraction pattern, while the electrons are reflected by the atoms close to the surface.

The preceding discussion gives one the background to appreciate how these diffraction methods may be used to advantage in petroleum chemistry. By way of illustration, some of the work where this has been done will be described.

Toluene from Hydroform

In 1942 there was an urgent demand for nitration-grade toluene, and the ordnance department turned to the petroleum industry to supply it. The process used for making much of the toluene from petroleum was the hydroforming process, which used an alumina-molybdena composite as the catalyst. This catalyst was relatively unstable in use, and deteriorated more rapidly than was desired with regard both to strength and activity. We, therefore, studied the catalyst problem to see whether an improved one without these unwanted properties might be developed.

Most of the catalysts of this type that we had studied seriously up to that time were made by impregnating the alumina with a solution of the molybdenum compound. These catalysts, when heated at high temperatures, or when used in a commercial plant, frequently suffered a change in crystalline structure, as shown by X-ray diffraction tests on the fresh catalyst and the used. The fresh material contained only anhydrous gamma alumina whereas the spent material contained a lot of alpha alumina, which is notoriously a bad actor in catalysis.

We speculated on these facts a little and reasoned somewhat as follows: Owing to the impregnation method by which the catalyst was prepared, the alumina surface was probably not covered uniformly by the molybdenum oxide; instead, the molybdena probably existed as globules on the alumina. Now it is well known that many compounds, such as sodium oxide, when added to pure alumina have the property of reducing the temperature at which certain crystal-

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lir.e changes occur. We suspected that the molybdena was behaving in this fashion, namely that it was acting as a flux to permit the alumina to undergo structural changes at very low temperatures. We argued, therefore, that this undesirable situation could be greatly minimized if the molybdena were distributed very uniformly throughout the alumina.

One way to effect such uniform distribution is to incorporate the molybdena into the alumina while it is in a wet hydrous state, rather than after it has been dried and compacted.

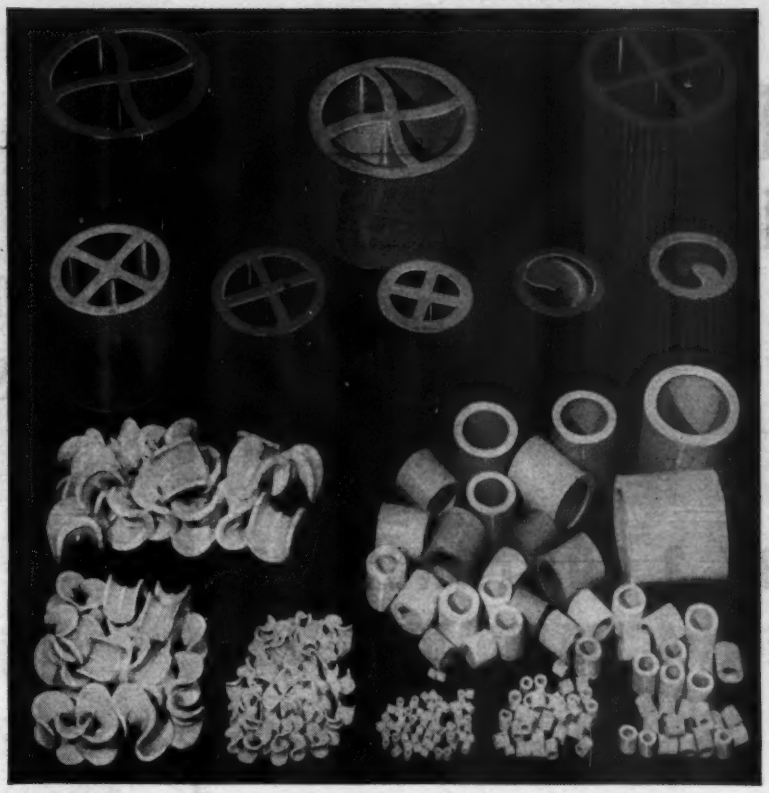
Now the method actually followed in testing this idea is the part of this story we wish to stress. Since the main object of this work was to develop a catalyst which would not suffer changes in its crystalline structure as a result of moderate heat treatment, and since it was known that these structural changes could be followed by X-ray measurements, a series of experimental samples of only about 1 gram was prepared, heat treated, and examined by X-ray diffraction methods. A relatively small amount of work was required to demonstrate that a catalyst of tremendously improved heat stability could be prepared by the method involving adding the molybdenum compound to the wet undried alumina hydrogel.

Following this, on the basis of the X-ray evidence alone, larger samples of catalyst were made and tested for their ability to produce toluene, and also to gain some idea as to their expected life under toluene-producing conditions. The results completely verified the conclusions drawn from the X-ray data. It might also be mentioned that the catalyst actually had an initial activity considerably higher than was expected.

This work has been described in some detail because it is an interesting illustration of how one can go directly to the fundamental properties of certain types of catalysts and reach conclusions of immediate practical application for the chemical technologists and refiners.

We have encountered a good many similar situations where X-ray and electron diffraction data have been of inestimable help in solving elusive problems. We have tried to indicate how the various radiations that are available to us interact with the materials used in petroleum technology, and we have seen how some of these interactions between matter and radiation are made use of in solving the practical problems of petroleum chemistry.

There are a good many more techniques, well known to the physicist, that can be used in the same way as those described, and they will have to be applied even more intensively in the future if the puzzling art of catalysis is ever made into an exact science.



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Shell's Wood River refinery's engineering department's 11 a.m. daily work-planning session is attended by maintenance zone supervisors, senior construction engineer, and assistant chief engineer

Refinery-Engineering Organization Has Manifold Responsibilities at Shell's Wood River Plant

by James F. Goldsberry

IN large refineries where improvements, plant changes, and extensions are continuous, and the daily maintenance orders number in the hundreds, the task of supervising, controlling, and keeping all jobs progressing in proper sequence or priority is indeed formidable. Such work is usually the responsibility of the engineering department, which, of necessity, has built up a large supervisory organization consisting of engineers, master mechanics, foremen, subforemen, and lead men. In addition, the staff is supplemented with industrial engineers, inspectors, and equipment specialists, such as lubrication, pump, and compressor engineers. A complete engineering office staff of designers and draftsmen is available when their assistance is needed.

Shell's Wood River refinery-engineering organization has developed procedures whereby complete knowledge of job status, personnel questions, and other facts necessary to a smooth-running organization are constantly before the supervisors. The growth of the organization has kept pace with the expanding refinery operations by careful selection of junior engineers, their training, and promotions. The technical and nontechnical supervisors work together harmoniously and cooperate wholeheartedly with the operating divisions in maintaining and expanding the units.

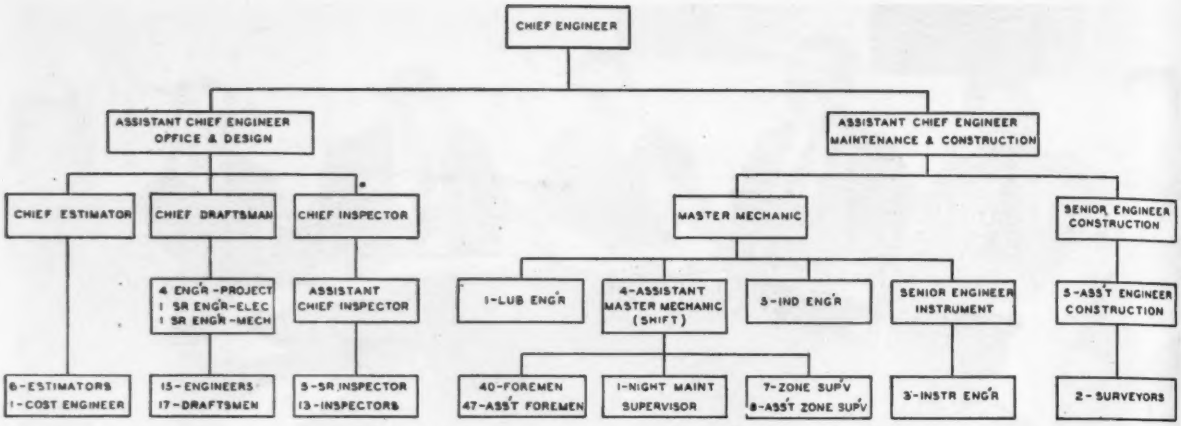
Shell's Wood River refinery-engineering organization consists of about 1,850 men of whom approximately 75 are technically trained. The organization is responsible for construction and maintenance and is staffed with men who are qualified in nearly every phase of engineering including those in special fields such as efficiency, lubrication, and the like.

Most of the engineers joined the organization directly upon graduation and receive advancements according to a fixed policy. Much thought is exercised in employing new men, who are interviewed according to a plan which is designed to determine if the individual will fit satisfactorily into the organization. Since employment of engineers is for replacement, final selection is based upon fitness for the specific job.

James F. Goldsberry, the author of this article, is chief engineer of Shell Oil Co., Inc., Wood River refinery. He is in charge of design, construction, and maintenance engineering. Prior to this time he served in a similar capacity at Shell's former Arkansas City, Kans., refinery. He graduated from Purdue University in 1921 and has been with Shell since 1926.

Such an organization usually consists of three divisions: maintenance, construction, and office design. In accordance with its size, it is further broken down into craft departments, as well as specialized departments, such as estimating, drafting, and inspection. Its methods have been revised and extended whenever necessary to keep in step with the growth of the refinery because an organization, like a large tool or piece of equipment, may become outmoded or obsolete. Extensions, personnel changes, and different methods are continuously being adopted in an effort to achieve improvement.

Often the chief engineer who once headed a small organization can remember that, in solving maintenance problems, he placed his hand on heated bearings or listened to peculiar sounds of operating equipment. He recalls being intimately connected with all routine maintenance, engi-



Wood River refinery engineering-organization chart

neering, and construction, and now, in the large organization, he finds himself separated from close contact with such work by assistants, master mechanics, and foremen. As the organization grew, he had gradually become immediately concerned only with the abnormal or serious problems, depending more and more on assistants, who, in turn, depended on master mechanics and foremen, for handling routine affairs. Thus, the effective or top supervision is some distance from actual job contact with the result that many decisions on planning or overcoming difficulties, the removal of the many obstacles preventing job progress, and the methods for expediting work pass into hands of other supervisory personnel under his jurisdiction.

Therefore, it not only becomes paramount in the large organization to select wisely the various levels of supervisors, but also to adopt methods whereby in delegating authority the top supervision knows the subordinate is keeping after the details. Complete knowledge of the details by inspired or self-directed supervisors will go far toward eliminating confusion, misplanning, and job chaos. Inspired supervision is found where the morale is high, where all appreciate the other fellow's job and have a sincere desire to cooperate. It prevails where everyone, the supervisor, engineer, and nontechnical man, has a medium of expressing himself, is able to talk freely without thought of prejudice, and is continually encouraged toward improvement. The successful organization will function so that no one is unnecessarily burdened, but with each man expected to carry his part of the load. All should be desirous of helping the other fellow, and this will be the case where the total effort of the organization is to act as a whole with the knowledge that all share in the credit.

At Shell's Wood River refinery, the engineering organization consists of about 1,850 men, of whom approximately 75 are technically trained. Included are engineers, estimators, designers, and draftsmen in the office; and field engineers, industrial engineers, master mechanics, and all types of craftsmen in the field who handle equipment maintenance and construction. The ranking positions in both office and field are filled by technical graduates. Nontechnical men are chosen as supervisors for most positions below that of assistant master mechanic.

It is necessary to maintain con-

(Continued on page 221)

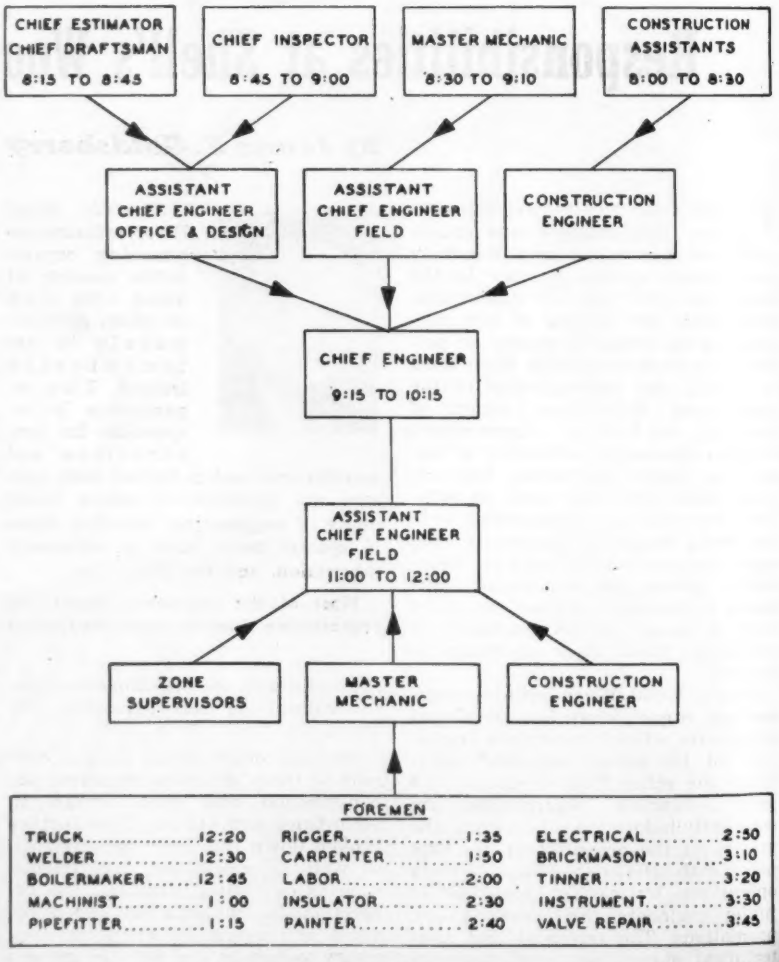
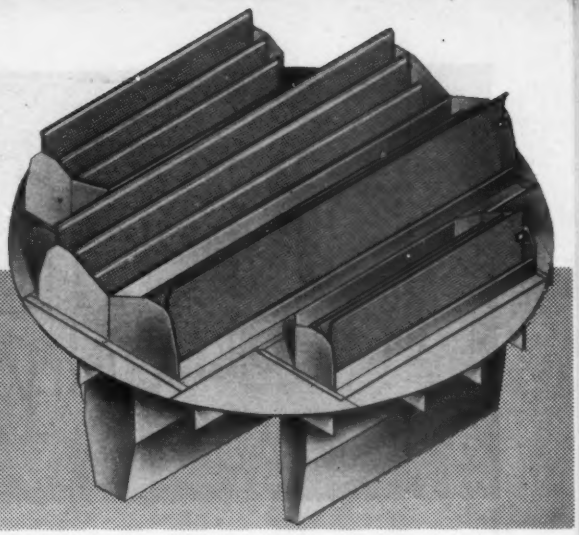


Chart of basic conference schedule

Complete assembly view of 6-foot Kaskade tray.



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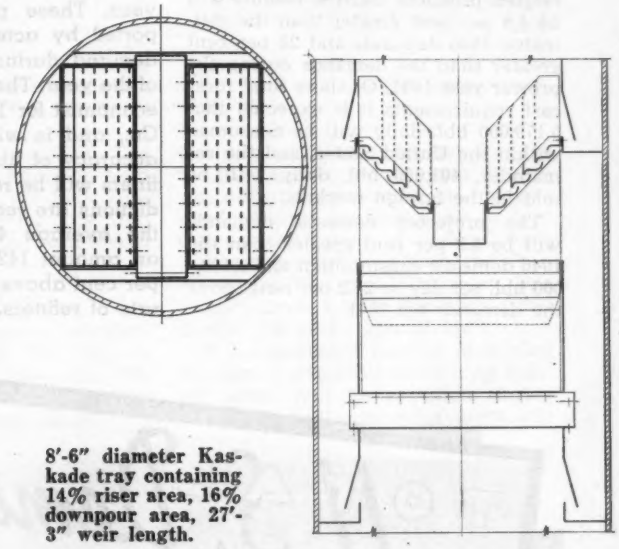
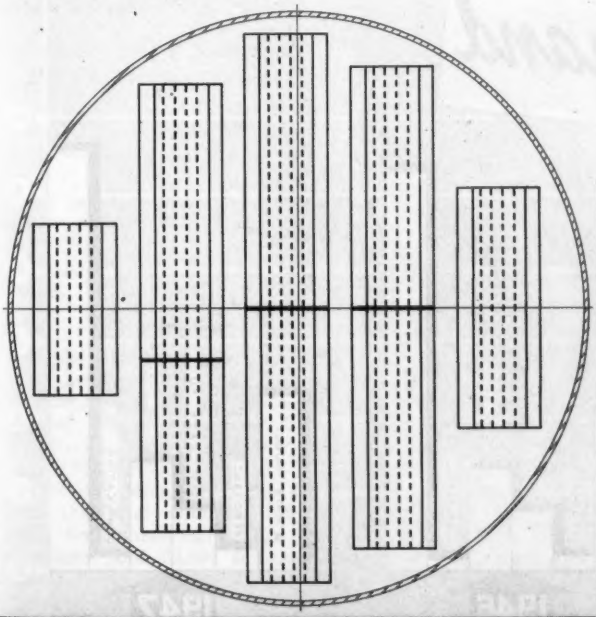
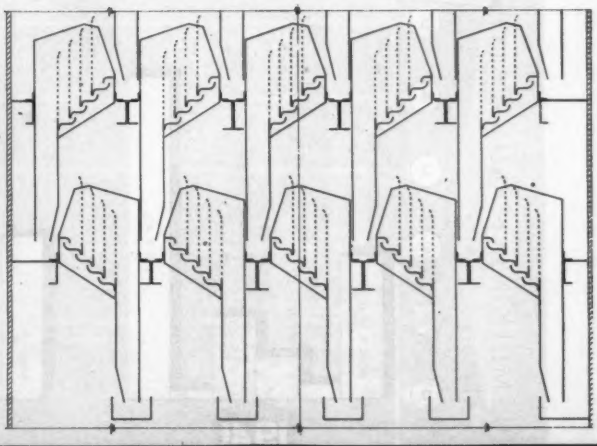


8'-6" diameter Kaskade tray containing 14% riser area, 16% downpour area, 27'-3" weir length.





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VOLUMETRIC OUTLOOK for the Oil Industry during 1947

by E. T. Knight

IT is here forecast that during 1947 the United States oil industry will supply approximately 5,580,000 bbl. daily of demands for petroleum and related products. Such a volume will be 4.9 per cent greater than the estimated 1946 demands and 28 per cent greater than the demands during the prewar year 1941. Of these total forecast requirements it is expected that 5,179,000 bbl. daily will be consumed within the United States, and the remainder, 401,000 bbl. daily, will be sold in the foreign markets.

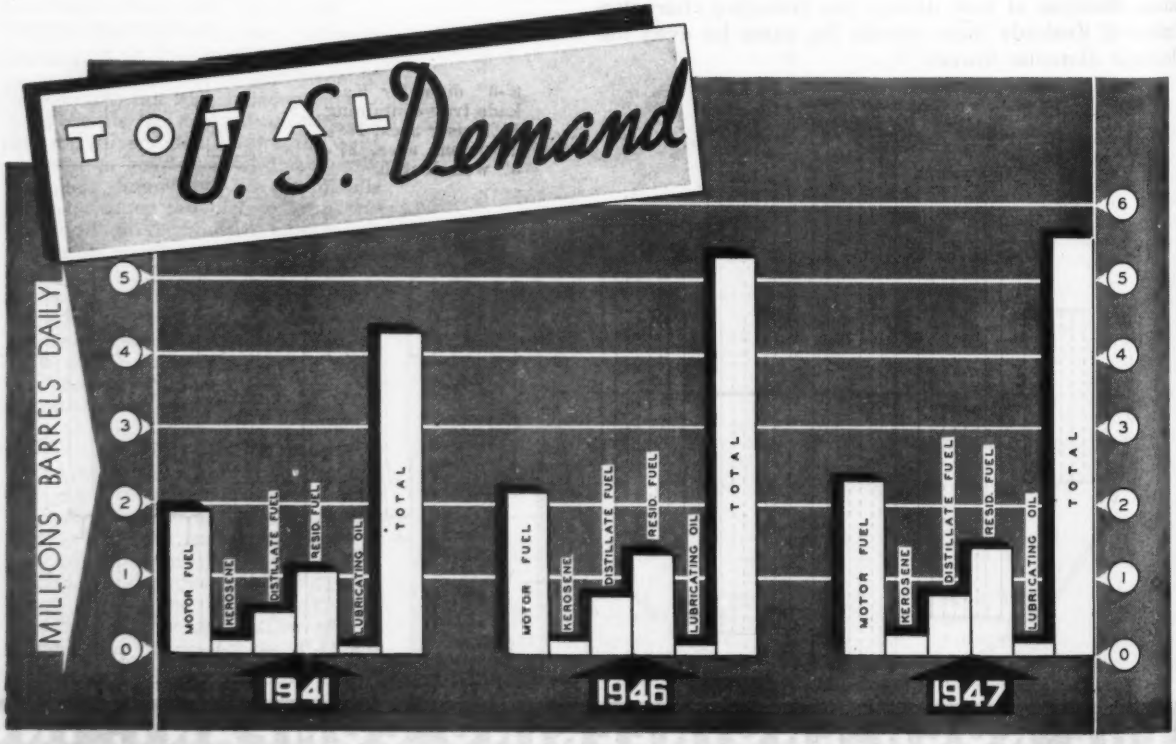
The projected domestic demands will be 5.9 per cent greater than the 1946 domestic consumption and 1,108,000 bbl. per day or 27.2 per cent above the demands for 1941.

The forecast for 1947 presented here is more optimistic than the favorable prognostications that appeared at the end of 1946, and earlier this year. These projections are supported by actual developments in demand during the first 2 months of the year. The author is petroleum economist for The Atlantic Refining Co., and is widely known for the accuracy of his forecasts. U. S. refiners will be required, if these predictions are realized, to process on the average 4,984,000 bbl. daily, an amount 142,000 bbl. daily or 3 per cent above the 1946 throughput rate of refiners.

The demands forecast for the year 1947 will be met by the importation of 392,600 bbl. per day of crude and products; the production of 337,600 bbl. daily of natural gasoline, condensate and benzol; and a daily production of 4,861,000 bbl. of crude oil.

The domestic crude production during 1947 will be 111,000 bbl. per day greater than the average production during 1946 when crude-oil stocks nation-wide were increased approximately 25,000 bbl. per day and the stocks of refined products increased on the average about 103,800 bbl. daily.

It is here considered that stocks of crude and products a year hence will approximate the current level of



stocks which is considered the minimum requirement for efficient operations.

If the projections of demands presented in the accompanying tables are realized, United States refiners will be required during 1947 to process on the average 4,894,000 bbl. daily, an amount 142,400 bbl. daily or 3 per cent above the 1946 throughput rate of the refiners.

Motor Fuel

A total demand for motor fuel of 2,287,000 bbl. daily of which 2,175,000 bbl. daily will be consumed within the United States is here forecast for 1947. Such a domestic demand will be 8.6 per cent greater than the 1946 demand and 18.9 per cent greater than the 1941 recorded domestic demand. Exports of motor fuel during the coming year will exceed those of 1941 by 50.5 per cent but will be 11.3 per cent below the 1946 rate of exports of motor fuel.

In projecting the demands for motor fuel it was considered that during 1947 the production of passenger cars in this country will approximate 4,000,000 of which perhaps 200,000 will be sold in the foreign markets. It was also considered that the number of passenger cars scrapped during 1947 will approximate 2,000,000, and the registration of passenger cars on December 31, 1947, will be 29,030,000. Registration of passenger cars December 31, 1946, approximated 27,230,000.

The production and scrapping of gasoline-consuming trucks and buses during 1947 will be at rates which will result in an end of the year registration of 5,723,000 as compared to an estimated registration on December 31, 1946, of 5,503,000.

The forecast consumption of motor fuel by categories of consumers during this coming year follows:

MOTOR FUEL AVERAGE DOMESTIC DEMAND

Class of consumers—	Bbl. dly.
Passenger cars	1,295,000
Trucks and buses	548,090
Aviation	35,620
Industry	169,860
Agricultural and nonautomotive	104,660
Government on-shore (excluding aviation)	21,920
Total domestic motor-fuel consumption	2,175,150

Kerosene

It has been forecast that the demand for kerosene during the coming 12 months will be at a rate approximating 252,000 bbl. daily. Such a rate will be 3.3 per cent below the indicated 1946 demand and 26.8 per cent above the demand for the year 1941. Of the total demand, 229,000 bbl. will be consumed within the United States and 23,000 bbl. daily will be supplied to foreign markets. The domestic demand will be 2.4 per cent below that of 1946, and exports will be 11.1 per cent below the 1946

FORECAST OF PETROLEUM DEMAND AND SUPPLY FOR 1947
(Barrels daily)

Demands—	1946*	% increase over 1941	1947 forecast	% increase over 1946	% increase over 1941
Motor fuel total	2,129,190	11.9	2,286,800	7.4	20.2
Domestic	2,003,310	9.5	2,175,150	8.6	18.9
Exports	125,880	†69.6	111,650	—11.3	†50.5
Kerosene total	261,220	31.2	252,600	—3.3	26.8
Domestic	235,020	23.5	229,320	—2.4	20.5
Exports	26,200	†197.1	23,280	—11.1	†163.9
Distillate fuels total	736,280	41.6	746,730	1.4	43.6
Domestic	641,850	35.6	657,700	2.5	38.9
Exports	94,430	†103.6	89,030	—5.7	†92.0
Residual fuel total	1,344,780	23.5	1,426,930	6.1	31.0
Domestic	1,318,450	25.5	1,399,530	6.1	33.2
Exports	26,330	†—31.9	27,400	4.1	†—29.1
Lubricants total	124,790	13.4	130,350	4.5	18.4
Domestic	94,490	14.0	100,220	6.0	20.9
Exports	30,300	†11.4	30,130	—0.6	†10.8
Other products (including refinery losses) total	577,880	38.1	595,680	3.1	42.4
Domestic	559,970	37.7	578,720	3.3	42.4
Exports	17,910	†51.1	16,960	—5.3	†43.1
Crude oil (as fuel, losses and export) total	143,750	11.3	141,530	—1.5	9.6
Domestic	38,830	1.8	38,350	—1.2	0.6
Exports	104,920	†15.2	103,180	—1.7	†13.3
Demand for all oils total	5,317,890	21.7	5,580,620	4.9	27.7
Domestic	4,891,920	20.2	5,178,990	5.9	27.2
Exports	425,970	†42.9	401,630	—5.7	†34.7
Stock changes all oils	+128,830	...	+10,410	...	...
Total new supply	5,446,720	25.5	5,591,030	2.6	28.9
Imports total	382,320	43.7	392,600	2.7	47.5
Crude	238,740	72.2	230,000	—3.7	65.9
Products	143,580	12.6	162,600	13.2	27.5
Domestic supply	5,064,400	24.4	5,198,430	2.6	27.6
Natural gasoline and benzol	314,500	36.2	337,580	7.3	46.1
Crude oil production	4,749,900	23.6	4,860,850	2.3	26.5

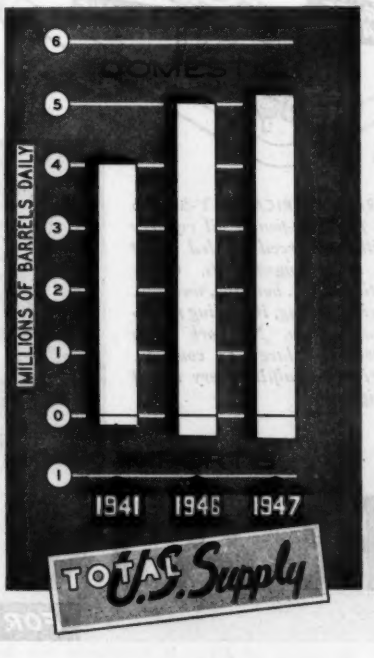
*Fourth quarter estimated. †Comparison of 1941 with 1946 and 1947 somewhat distorted by the effect of war on foreign markets in 1941.

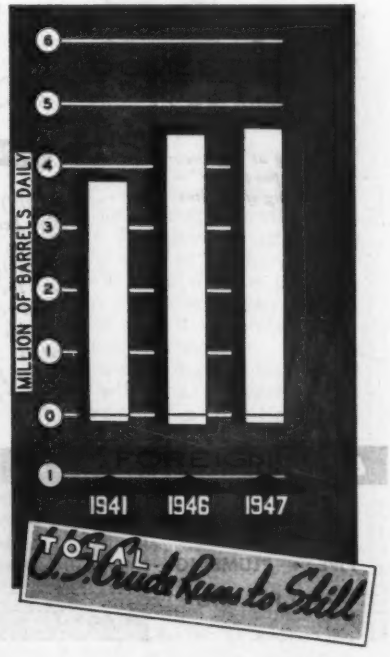
shipments to foreign countries. The decline in domestic consumption from that of 1946 results from high consumption recorded during the first half of that year being considered unseasonal.

Distillate Fuel

The projected domestic distillate consumption of 658,000 bbl. daily is 2.5 per cent greater than the 1946 domestic demand. This demand has been forecast to increase despite the fact that distillate fuel demand for the first and second quarters of 1946 was distorted upward by the employment of some distillate fuels to supplement the supply of residual fuels and by shipments to jobbers and dealers during that period to meet their requirements which were not filled during the latter part of 1945.

It is anticipated that an increasing number of domestic oil-burning heating units will be recorded during 1947. Diesel-oil-consuming units will





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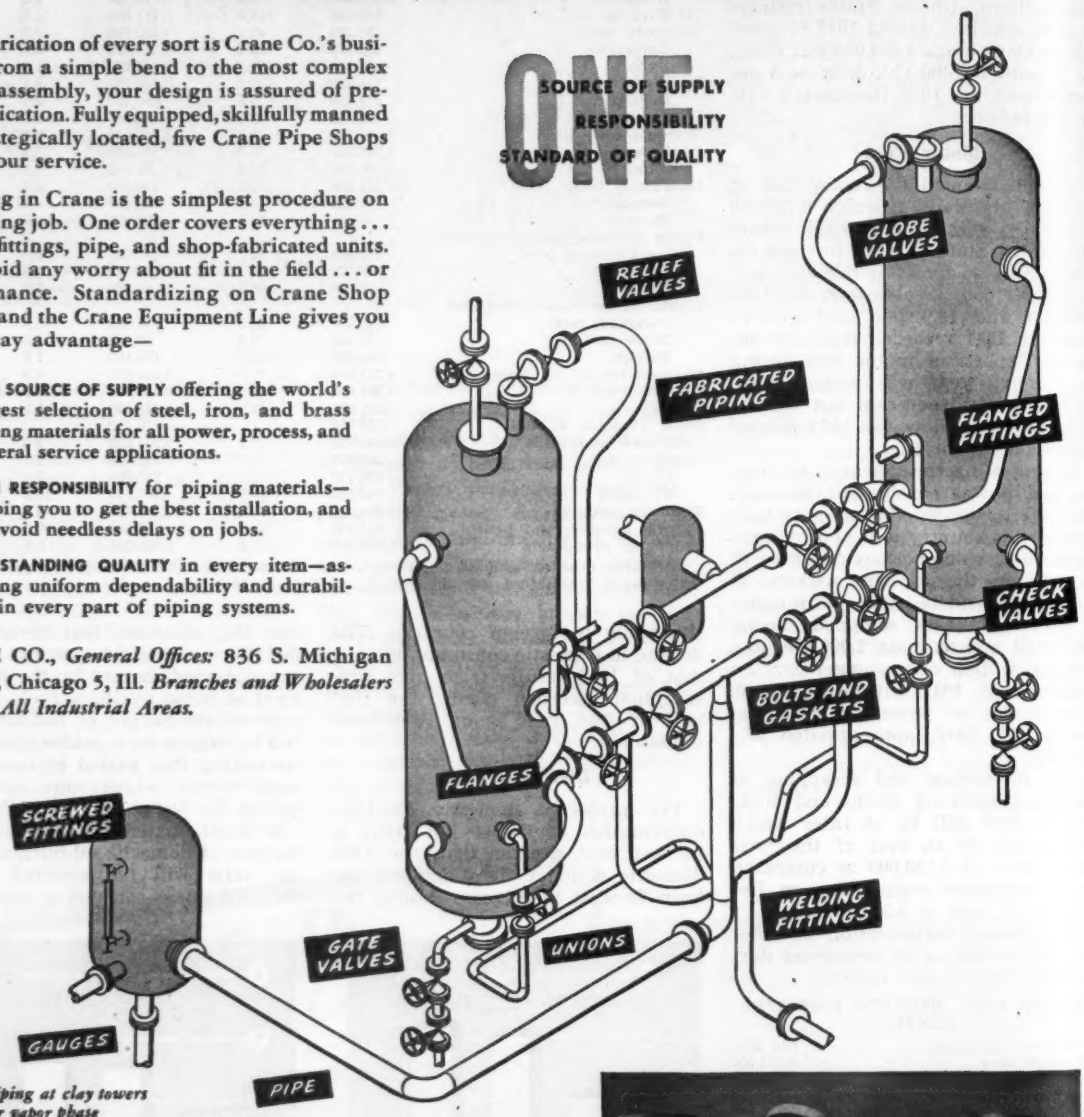
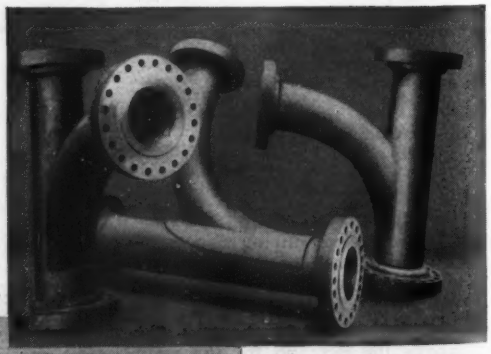


Piping at clay towers for vapor phase treating of gasoline



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be increased markedly during 1947, especially in the transportation field where diesel locomotives and buses have gained increased acceptance.

motive units and the relationships of these demands to the 1946 and 1941 consumption are presented below.

UNITED STATES REQUIREMENTS FOR LUBRICANTS
(Barrels daily)

	1946		1947		
	Bbl. per day	Per cent increase from 1941	Bbl. per day	Per cent increase from 1946	Per cent increase from 1941
Motor oils	47,200	14.3	52,000	10.0	26.8
Industrial oils	47,200	13.4	48,000	1.7	15.5
Total	94,400	14.0	100,000	6.0	20.9

Residual Fuel

These forecast data for 1947 consider that United States consumers of residual fuel oils will require 1,400,000 bbl. daily, an amount 6.1 per cent more than was required during 1946. The 1947 demand as projected will be 33.2 per cent greater than the 1941 daily domestic consumption.

The forecast domestic consumption of lubricants by industry and automotive units and the relationships of these demands to the 1946 and 1941 consumption are presented below.

It is expected that during 1947 the consumption of motor oil will increase relatively more than motor-fuel consumption, since the average age of consuming units will be greater.

Shipments to foreign consumers during 1947 will approximate 30,000 bbl. daily, an amount equal to the 1946 export shipments.

The summaries of the foregoing forecasts of demands are presented in the accompanying tables.

OVER-ALL SUPPLY AND DEMAND OF PETROLEUM AND RELATED PRODUCTS
(Barrels daily)

	1947	% change from		1946 (est.)	
	B/D	1946	1941	B/D	% change from 1941
Total demand	5,580,700	+4.9	+27.7	5,317,900	+21.7
Stock change					
Crude and products	+10,400	...	...	+128,800	...
Total required supply	5,591,100	+2.7	+28.9	5,446,700	+25.5
Less:					
Imports of crude and products	392,600	+2.7	+47.5	382,300	+43.6
Prod. of related products*	337,600	+7.3	+46.2	314,500	+36.2
Crude oil production	4,860,900	+2.3	+26.5	4,749,900	+23.6
Less:					
Transfers, as such and losses	98,300	—8.1	+22.3	107,000	+33.1
Crude oil exports	103,200	—1.6	+13.3	104,900	+15.2
Stock change	—4,700	...	...	+25,000	...
Runs to stills					
Domestic crude	4,664,100	+3.3	+25.3	4,513,000	+21.2
Foreign crude	230,100	—3.6	+66.0	238,800	+72.2
Total	4,894,200	+3.0	+26.8	4,751,800	+23.1

*Natural gasoline, L.P.G. and benzol.

DEMANDS FOR SPECIFIC PETROLEUM PRODUCTS
(1,000 Barrels Daily)

	1947	% increase from		1946	
	1,000 B/D	1946	1941	1,000 B/D	% increase from 1941
Domestic demand					
Motor fuel	2,175	8.6	18.9	2,003	9.5
Kerosene	229	*2.4	20.5	235	23.5
Distillate fuels	658	2.5	38.9	642	35.6
Residual fuel	1,400	6.1	33.2	1,318	25.5
Lubricants	100	6.0	20.9	94	14.0
All other and losses	617	2.8	38.5	600	34.6
Total domestic	5,179	5.6	27.2	4,892	20.3
Exports					
Motor fuel	112	*11.3	†50.5	126	†69.6
Kerosene	23	*11.1	†164.1	26	†197.1
Distillate fuels	89	*5.7	†92.0	95	†103.6
Residual fuel	27	4.1	*†29.2	26	*†31.9
Lubricants	30	0.0	†11.1	30	†11.1
Crude oil	103	*1.6	†13.3	105	†15.2
All others	17	*4.5	†41.5	18	†51.1
Total exports	401	*4.8	†34.5	426	†43.0
Total demand					
Motor fuel	2,287	7.4	20.2	2,129	11.9
Kerosene	252	*3.3	26.8	261	31.2
Distillate fuels	747	1.4	43.6	737	41.6
Residual fuel	1,427	6.1	31.0	1,344	23.5
Lubricants	130	4.5	18.4	124	13.4
Crude oil export	103	*1.6	13.3	105	15.2
All other and losses	634	2.5	38.5	618	35.0
Total demand	5,580	4.9	27.7	5,318	21.7

*Decrease. †Comparison of 1941 with 1946 and 1947 somewhat distorted by effect of war on foreign markets in 1941.

Shell's Engineering Organization

(Continued from page 214)

stantly a qualified engineering department with sufficient flexibility to handle all phases of engineering, such as electrical, mechanical, civil, structural, architectural, and other types associated with petroleum engineering. Efficiency, industrial, lubrication, and many other forms of special engineering are also handled by the department. Special knowledge of metallurgy, ceramics, and chemistry is needed. In fact, there is scarcely any phase of engineering not employed in a large refinery. The engineers may be called upon to design a hospital, a cafeteria, or shops, or build roads as well as to design a processing unit.

With the foregoing in mind, it is readily apparent that a qualified and diversified engineering organization must be maintained; it needs to be staffed with competent engineering supervisors who are alert, aggressive, and inspired, and with leaders who basically believe there is always room for improvement.

An engineering organization headed by such personnel will qualify in the following manner:

1. It accepts responsibility.
2. It is economical and cost minded.
3. It keeps abreast of latest developments.
4. It maintains the operating department's faith.
5. It is over-all company minded instead of engineering-department minded.
6. It is proud of accomplishment.

1. **It accepts responsibility.**—Once operating departments and management feel an engineering department will assume full responsibility, it will be permitted to do so. In other words, an engineering department will be delegated as much responsibility as it has shown the ability to assume. It should feel an obligation to keep the units running, to keep downtime to a minimum, to prevent premature breakdowns, and to perform high-quality work. Once work is assigned, it is not up to the operating departments to see that it is completed or done in a qualified manner.

The engineering organization might compare itself to a contractor who has been awarded a job. He agrees to do the work according to specifications and is held strictly accountable for completion and quality of work. Quite naturally, he will expect extras and additions for any obstacles placed in his way, such as failure to have unit ready, change of plans, or delayed decisions, etc. In return, if he is to make a profit and continue being awarded contracts, he gets the job done as quickly as possible and avoids being called back to correct inferior

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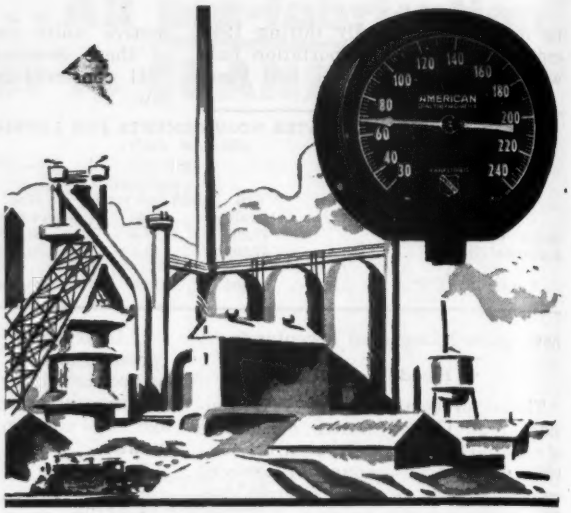

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workmanship. In some cases, supervisors do not appear to regard the fact that having to do jobs over is a reflection on the supervision. However, a contractor would not stay in business if he failed to take serious heed of the cost resulting from poor craftsmanship that engineering departments often experience.

The objections to awarding cost-plus contracts are well known, yet most refinery-engineering departments operate on the same basis only without the plus. The evils of the cost-plus method of doing work can easily be reflected in an engineering department's handling of assignments from the operating department. It is difficult to imagine an instance where contracts would be let on the basis on which an engineering department actually is given jobs; that is, if a compressor is broken down, it is simply handed the job—often it is not asked to make an estimate of the possible cost. It is accountable for the cost, but only too often there is no check or investigation of the expenditure. Therefore, an engineering department is on its honor to do an economical job, and it is up to the supervisors to avoid criticism due them if they fail to accept the responsibility of making the cost of the department's service attractive.

2. **It is economical and cost minded.** This is an important trait in any engineering department. It assumes the responsibility of seeing that the company gets a dollar's worth of labor or material for every dollar it puts out. This definitely reflects itself in the profits of the company.

To be sincerely cost conscious and economically minded, it should give constant attention to waste in both materials and labor. Active cooperation of all supervisors is a powerful method of eliminating waste. More than just a casual responsibility for repetitive maintenance should be assumed. It reflects on an engineering department when it just makes repairs and fails to see the why and wherefore of the breakdown or failures.

Actually, a study of almost any job in the plant from replacing pump packing to handling a unit shutdown will show that improvements can be made. Toward this end, at Shell's Wood River refinery, technical aid in the form of industrial engineers has been assigned to the foremen. They investigate repetitive maintenance and help the foremen do the job with the idea of preventing recurrence. As an example, an engineer investigates all bearing failures. A bearing is not just replaced without our knowledge if it failed due to contaminated lubrication, misalignment, expansion, or other possible causes. Technical investigation is assigned to any extraordinary maintenance.

In being cost conscious, it is necessary that an engineering department adopt a keen sense of obligation and be sincerely interested in eliminating wastes.

3. **It keeps abreast of latest developments.**—New equipment and tools that may be less awkward or require less labor, and new or more specific materials are constantly being placed on the market. One can hardly look at magazines or equipment articles without coming across items that would improve or lower costs.

In general, it is best to scrutinize closely all maintenance equipment 10 years old or older. Frequently, higher-quality work results from discarding aged equipment, and generally excessive maintenance is avoided. Better results, or materials more suitable for specific use, may be obtained by contacting with suppliers; and, it is a good policy to exchange ideas with representatives of manufacturing concerns. Contacting with other divisions within a corporation will also often result in new ideas, equipment and materials.

An engineering department is expected to be constantly on its toes and alert to take advantage of all avenues for improvements.

4. **It maintains the operating de-**

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partment's faith.—This, on first thought, may not appear to be an important characteristic of a qualified engineering department; but the work of an engineering organization is much easier where such faith exists. If the operators feel there is a genuine interest in their welfare, a definite disposal to cooperate and a sincere feeling of obligation to discharge responsibility, rarely will they ask the impossible, or even as the saying goes, "get in the engineering department's hair." They want and appreciate help. They will rely on the engineers' judgment, their decisions and plans, provided, by actual practice, the faith his merited. If an engineering department truly serves, any problem the operators have should be placed in its hands with the feeling that something will be done about it. It is not enough to say—it cannot be done or just sit on it. It is necessary to find a way. The operators will tell an engineering department how to plan its work and discharge its duties, however, if they experience procrastination and little interest in their assignments.

Operators want and will support an alive aggressive maintenance department. They will interfere very little if an engineering organization's technical ability is sincerely at their disposal and every effort is made to aid them.

5. **It is over-all company minded instead of engineering-department minded.**—Sometimes an engineering department may try to mold operation to suit the best interests of the maintenance division. That is, it objects to abrupt change of scheduled downtimes, emergency call for overtime, heavy drag on supervisory time time for so-called "hot jobs," etc.

It is only necessary to remember that the operators frequently have their plans changed and they encounter demands for the products of which an engineering department is not always aware. The engineering department is a service department and comes second when it is a case of production. By the nature of the department's work it has to be ever ready to fall in line with the plans or changes required by operators. It is discouraging to have well-laid plans disrupted but only to a certain extent can a refinery engineering department operate on a routine schedule. Its basic job is to make petroleum products and any interference with its plans can usually be attributed to the welfare of the company as a whole. An engineering department is not actually doing any favors nor does the operating department particularly owe any thanks when the department aids the operators in every way to make their products in the most economical manner.

In the last analysis, the company manufactures products at a cost to meet competitors. An engineering department is just as much a part of the company as the operators and, although it is true and helps a lot to be reminded of a job well done, doing a good job is an engineering department's obligation. However, as a rule operators are generous with their praise and appreciation when kept out of trouble or when difficulties are eliminated from operation.

6. **It is proud of accomplishment.**—An engineering organization possessing the five characteristics already mentioned will achieve and accomplish much. The individual engineers' morale will be high; they can hold their heads up; they will feel confident and successful knowing they have the faith and backing of the management. Every unit restored to operation a little sooner or at less cost will add to this confidence; and, what is more important, if the ranking supervisors of the engineering department feel this way, some of that feeling is bound to permeate into the feelings of those having lesser responsibility, and so on down the line to the craftsmen. There is no greater motivating power than the feeling of pride in achievement or accomplishment. No doubt, many other traits of a successful organization could be mentioned, but most of them will follow in line if an organization possesses characteristics described.

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So far, a qualified engineering organization, as a whole, has been considered. It is well to dwell on the type of men who would make up such an organization—the characteristics and traits which engineers possess that together form a successful engineering department — the traits we should look for in selecting junior engineers to fill vacancies—the particular qualifications that should be required for promotion to the higher supervisory personnel.

Shell's Wood River refinery's engineering organization is composed of engineers, mostly employed direct from colleges. It is a practice to promote young engineers, as soon as they are properly trained, to higher positions whenever vacancies occur In drawing from the ranks of the already-employed engineers instead of bringing men in from outside for the senior positions, the morale of the younger engineers is maintained. It is also felt that this practice helps in attracting alert and promising men for employment.

Years of experience have taught us that a competent engineering organization wil function automatically if proper attention is given to the selection of junior engineers, their training and promotions, and the molding of practical and technical knowledge so that the young engineer is cognizant of his obligation and can meet his responsibilities.

In such an organization, much depends on individual happiness and satisfaction if the whole is to be successful. Therefore, after the junior engineer has been trained and is ready for promotion, much attention is given to placing him on the right job. Some men belong in the office on work such as insurance appraisals or invoice approvals; others do best out of doors; some make designers or investigators, while others are best fitted for supervisory positions. Also in selecting a replacement, it is not always true that simply because a man is highly satisfactory in one form of work, he will be likewise in other types of employment.

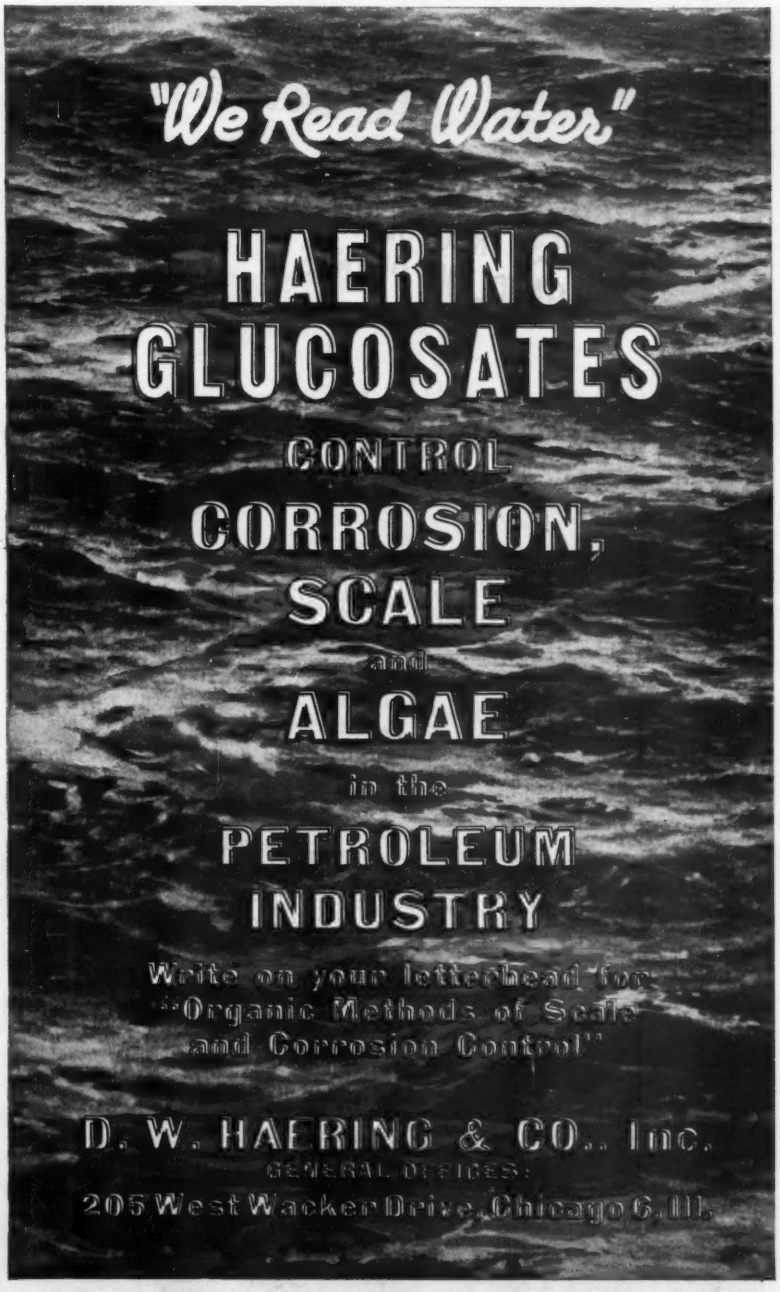
A good organization will strive to have intelligently selected men ready for all vacancies. The senior engineers will feel it a sound policy and an obligation to help train the younger men to step into the senior positions. This makes further promotion of the senior engineer possible without interfering or interrupting work.

Since the future quality of an engineering organization depends to a large extent on the junior engineers, and all replacements are indirectly from the ranks of such men, much thought is exercised in employing them. It is difficult to visualize a junior engineer 5 years hence. If we could, most of our problems, as well as his, would vanish. So, reliance is placed on applications and on well-planned and sincerely conducted interviews.

It is felt that the characteristics most valuable in determining how promising a young engineer may be at the time of his employment interview are as follows:

1. Extent of having acquired sound engineering fundamentals.
2. Attitude, such as sincerity and conscientiousness.
3. Lack of acting or artificial impressiveness.
4. Extent of inspiring confidence and admiration through poise, appearance and personality.
5. The indication of more than average breadth of knowledge.
6. A questioning attitude in regard to the company—types of jobs and future possibilities.
7. A fair use of good grammar and vocabulary.
8. Average social likes and dislikes.
9. Some display of initiative and sound judgment.

The chief function of an engineering organization is in the field. It is here that the most money is spent and by far the greater part of the organization is employed. The non-technical man plays an important part in field operations. It is here,



too, that judicious use of time and materials is so important.

As anyone responsible for maintenance and construction work knows, many jobs, though well planned, fail to run smoothly and often are accompanied by some interference, such as insufficient materials, delayed safety permits, improper tools, craft services not coordinated, and various unforeseen obstacles arising once a job is started. All such factors contribute to delaying a job, and, unless they are promptly taken care of under the proper supervision, the jobs will drag to a point where operation bears a considerable burden. As the major controllable expense is usually labor, the difficulties resulting in lost manhours should be ironed out in advance if the work is to be done at reasonable cost.

Benefits of Planning

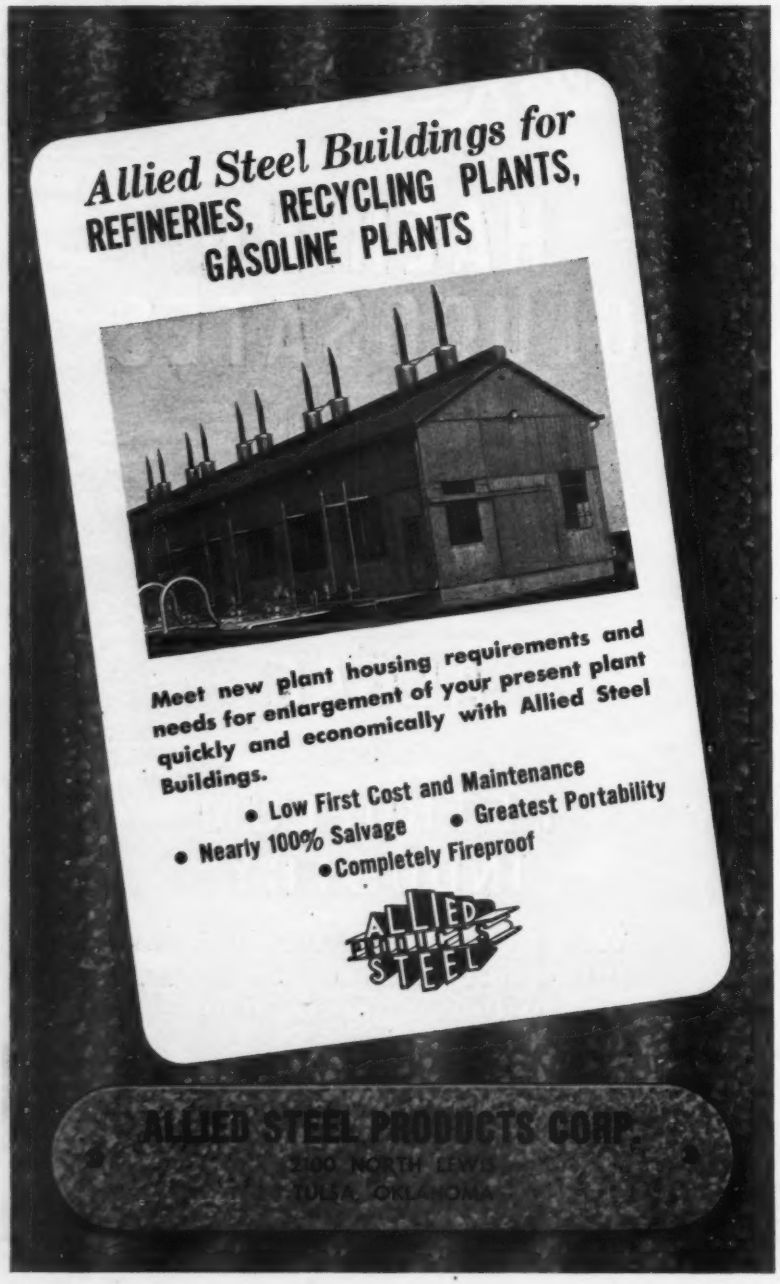
The extent of success, or what is known as "sourness of a job," will, in practically all cases, depend on how well a job is planned and to what extent it is controlled. A study of most jobs not proceeding according to expectations will generally reveal lack of proper information or preparation by the immediate supervisors. It is true that some difficulties will arise in spite of the best efforts on the part of supervision, but it is well for supervision to analyze itself carefully when attempting to determine lack of job progress.

The average workman wants to do a job right and in an efficient manner. He responds to a well-organized job and will respect and work willingly for effective leadership. Avoidable delays due to frequent changing of plans, improper methods, and particularly indifferent or poorly qualified supervisors tend to cause confusion and distraction in the mind of the workman. Such conditions will result in his adopting a lackadaisical or "hands up" attitude. The benefit of good employe morale is fully realized and it requires that, in addition to first planning the jobs, some definite means should be provided for the top supervision to know that the plans are being carried out or be informed of obstacles arising to prevent work progress.

To promote this effectiveness and to keep all work within the scope of the supervisors, the Wood River refinery engineering department employs a system whereby the supervisors possess sufficient information on the status of the jobs at all times to be able to detect lagging work, probable overexpenditures, and particularly repetitive maintenance. The more familiar these supervisors are with the progress of the many jobs proceeding at the same time, the more efficiently the work will be performed. Obviously, it is impossible for top supervision to visit and inspect hundreds of jobs daily as a method of obtaining this information.

Daily conferences in which all supervisors take part are employed to bring before engineering management the progress of the planned work. Routine conferences enable top supervision to keep in touch with the performance of the individual to whom the responsibility has been given and provides for the removal of obstacles beyond his control. It insures progress in all the work and gives a picture of the volume of incomplete projects. The preparation of reports requires that the assistants post themselves on the information, thus insuring their close contact with the work. Obstacles to job progress are less likely to repeat themselves where an admission is made, especially when due to laxity on the part of supervision.

On first thought, it might seem that conferences aided by reports would consume too much of the supervision's time. However, much can be accomplished in a few minutes where alert and businesslike conferences are held; also, the conference affords an opportunity for top supervision to teach and train other supervision wherein its responsibilities lie, the ineffectiveness of "passing the buck" and the necessity of being aggressive, honest, and fair.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Separation Plant

(Continued from page 190)

The separation plant is located approximately 500 ft. from the mine. For the present, mining will be handled by a power shovel and dump trucks. During the past summer approximately 10,000 cu. yd. of sand were excavated and moved in this manner during the course of construction. Wear of the shovel teeth and bucket was not regarded as excessive and the dump trucks were able to discharge their loads without difficulty.

After a consideration of the factors involved, it was decided that the new unit should be capable of processing a minimum of 350 yd. of sand per day if it was to provide all the information desired as regards operation, etc. On this basis and using information obtained from operations of the original pilot plant, company engineers prepared flow sheets and heat and material balances for the new unit. To further assist in the design work a small pilot plant was built in the laboratories of Alberta Research Council. This unit proved of invaluable assistance as small runs could be made under almost any desired set of conditions.

Early in 1945 Born Engineering Co., of Tulsa, and its Canadian associates, Canadian Brown Steel Tank Co., of Brandon, Man., were retained to assist in the design and fabrication of special equipment and to make all drawings required for construction.

Construction Problems

Since the scene of operations is 250 air miles north of Edmonton and 50 miles beyond the end of steel at Waterways, much preparatory work had to be done before actual construction got under way. The company obtained its own tugs and barges to transport equipment from Waterways down the Athabaska River to the plant site. During the navigation season in 1946 over 1,500,000 lb. of equipment and supplies were moved by this means.

Due to the high cost of lumber and the uncertainty of supply a sawmill was erected and all the lumber required was manufactured on the job.

Modern living facilities were provided as well as machine shops, garages, office, and laboratory, since a construction crew working in this locality must be completely self-sufficient. To maintain communication with the home office in Edmonton a two-way radio was installed and weekly air-mail service established.

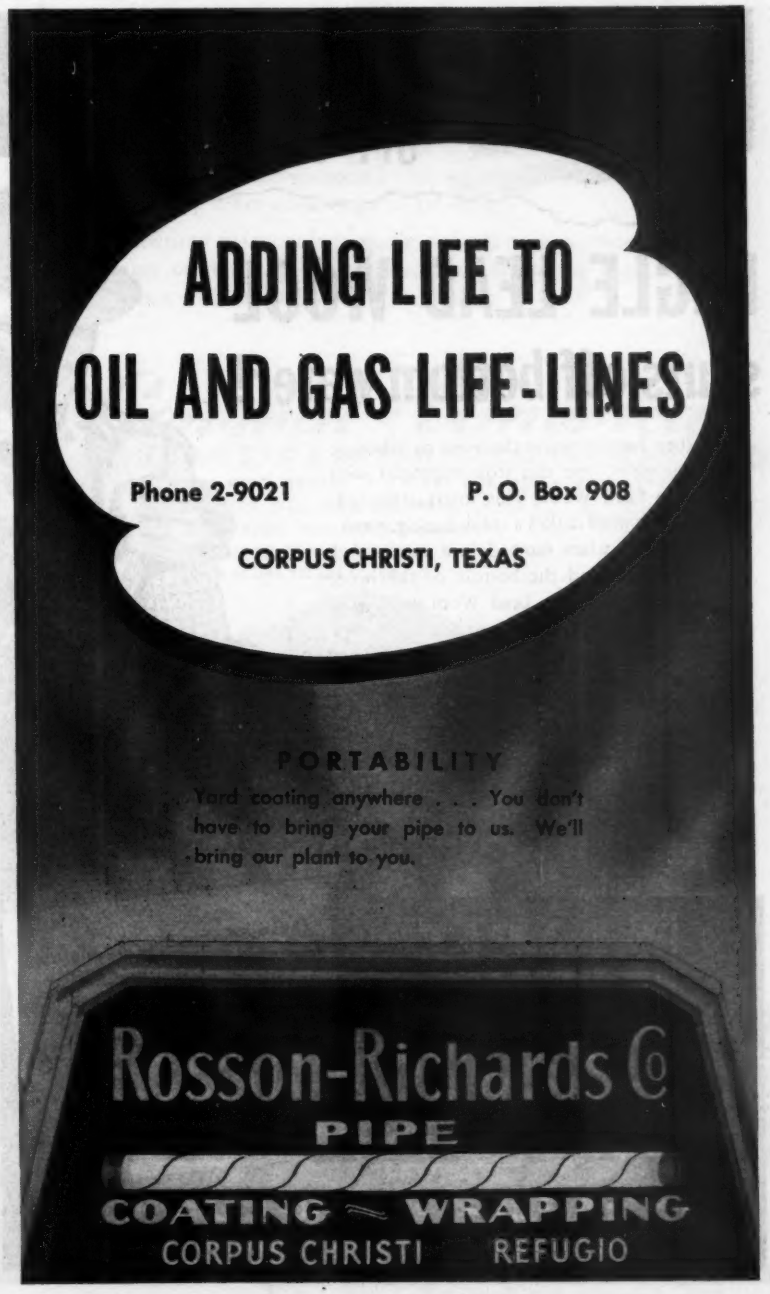
Actual construction of the plant proper got under way in the early part of 1946.

Description of Plant and Process

The works can be roughly divided into three main units: separation plant, refinery, and power house.

The separation plant is housed in a two-story structural steel and galvanized iron building 55 by 40 ft. In order to facilitate delivery of sand from the mine to the plant, this building with the raw-materials hopper adjoining it is being erected in a large excavation on the river bank, the top of the raw-materials hopper being slightly higher than the top of the bank. Dump trucks operating from the mine, on the upper level, will drive onto an unloading area surrounding the hopper and discharge their loads directly into the hopper.

The lower sections of the hopper are equipped with steam and water jets to facilitate discharge of the oil sands from the hopper to the screw conveyors which move the sands forward into the separation plant. On entering the plant the sand is first screened to remove any foreign objects which might interfere with operation of the screw conveyors. The sand is next agitated with boiling water in a paddle mixer for a period of approximately 15 minutes during which time the oil film surrounding each grain of sand is scrubbed off and replaced by a water film. At the same time a certain amount of aeration of the oil takes place. This aeration is tremendously important since the oil being approximately 10° A.P.I. could not be floated without it. Prior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to flotation in the separation cell, further air is added at the sand distributor. The amount of air added at this point must be controlled carefully and varied in proportion to the rate of feed, degree of saturation of the sand, etc. In the separation cell, which is also maintained close to 212° F., the oil floats and is removed to the settling tank in which it remains for approximately 6 hours at 200° F. Mineral matter which is deposited in the settling tank carries oil down with it since some of the air has escaped, and consequently it is necessary to recycle these settlings to prevent waste.

Sand tailings from the separation cell are removed by screw conveyors and elevated to a point above the liquid level in the cell before being deposited in the sand receiver. A sand pump taking suction on the receiver discharges the sand to the tailings dump, which for the present will be located in a ravine on the north side of the separation plant.

The process water is withdrawn from the separation cell at a uniform rate and settled to remove silt accumulations before being reheated and returned to the circuit. Withdrawal and recycling of process water is handled by two 500-g.p.m. centrifugal pumps. Water is heated by steam in tubular heat exchangers.

Each conveyor is equipped with variable motorized reducers so that operating conditions may be altered for experimental purposes.

All vessels are vapor-tight and the whole structure is of fireproof construction. These precautions have been taken to eliminate the fires which have been responsible for interrupting operations at another plant on at least two occasions.

Refinery

The separated oil contains as high as 30 per cent water at times. Prior to being pumped to the refinery the oil-water mixture is diluted with a 550°-e.p. distillate in the ratio of one part distillate to two parts oil, dilution being controlled by a ratio flow controller. This facilitates handling and also permits removal of a large part of the water by a simple settling operation. Under average conditions water content after the settling operation is around 10 per cent of the original oil present. This remaining water presents a problem in that it appears to be impossible to remove by standard methods. Many experiments were made, including electro settling in an effort to eliminate this water, all without success. It was finally decided to flash off the water prior to refining and to do this a small tube still is being built in which the oil water distillate mixture will be raised to 350° F. and then flashed into an 18-ft. flash drum. It is expected that when the refinery proper is in operation sufficient heat will be recovered by heat exchange to make the use of the heater unnecessary.

The crude from the oil sands is unique in its susceptibility to heat treatment, thermal decomposition starting at temperatures below 500° F. In view of this characteristic it is virtually impossible to subject the crude to any ordinary refining operation without some cracking taking place, and consequently while the refining operation presently contemplated will be a straight topping proposition in most respects, it will of necessity have some of the characteristics of a cracking process. After careful laboratory evaluations, it was decided that the heater outlet should be carried at 750° F. and while considerable decomposition takes place at this temperature deposition of coke is slight and it is anticipated that the presence of the distillate in the crude will increase velocities to a point where coking will be little, if any, problem. The discharge from the heater is carried to a flash tower to prevent any possibility of coke carrying over and accumulating on the trays of the fractionator. Products of the present operation will be a small quantity of gasoline, larger quantities of distillate and gas oil, and the remainder representing approximately

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65 per cent of the charge, will be a heavy fuel oil.

The refinery has been so designed that the addition of a small continuous coking unit would permit the manufacture of a full line of fuel products and the elimination of the heavy fuel oil. When and if the coking unit is added the coke will be used as fuel in the boiler house. Grates as well as oil burners are being installed in the boilers to meet this contingency.

Power House

Without coking it is not expected that the operation will be commercial and the refinery will aim solely at the production of fuel oil and distillate for the separation plant and power house.

Steam requirements for the whole operation will be generated by two two-drum water-tube boilers rated at 6,000 lb. per hour each. As mentioned above these boilers are equipped to be fired with either oil or coke. Electric power is to be generated by a turbogenerator rated at 125 k.v.a. while a diesel generator rated at 62.5 k.v.a. will handle peak loads and provide power during shutdowns and emergencies. Both electric and steam-driven compressors are being installed to assure an ample and continuous air supply.

Water will be drawn directly from Athabaska River and there will be a battery of two filters as well as a chlorinator to treat water for camp use.

The power-house building is of structural steel and galvanized-iron construction 70 ft. by 35 ft.

Costs

Total completed costs of the plant are now known with a fair degree of accuracy and these indicate that the investment per daily barrel of production will be approximately $1,010. This includes mining equipment, separation plant, and 60 per cent of the investment in the power house (portion allocatable to separation). It has been calculated that the investment per barrel of daily production in Turner Valley at present is approximately $3,460.

The project has now advanced to a stage where a visualization of operating procedures can be made with a high degree of accuracy and on the basis of these studies, it is estimated that operating costs will be approximately as follows:

Item—	Costs per day	Cents per bbl.
Stripping*	$3.43	0.98
Mining†	85.95	24.6
Separation†	127.40	35.4
Power steam, etc.†	89.80	25.6
Royalties	3.50	1.0
Clerical and laboratory	12.00	3.43
Supervision	20.00	5.5
Insurance	10.00	2.85
Total	$382.08	99.36

*Based on 4 ft. of overburden which is depth at present time. †Includes depreciation and maintenance on equipment.

Future Prospects

Assuming that these estimates are reasonably accurate it can readily be seen that on a large-scale operation operating costs will be well below $1 per barrel What economies can be effected in operation are difficult to predict; however, the largest manufacturers of earth-moving equipment in the world feel confident that on a large operation mining costs would not exceed 15 cents per cubic yard. This estimate is based on a survey made during the past summer. Since the separation process itself is relatively simple it is likely that actual separation could be carried on for a maximum of 50 cents per barrel placing the over-all cost per barrel in the neighborhood of 65 cents on a large operation. It is also felt that the investment per barrel of daily production could be greatly reduced in a large plant, which would further affect the over-all picture as regards costs.

For further information the reader is referred to various publications by K. A. Clark of Research Council of Alberta, Universal Oil Products Co., and the Department of Mines, Ottawa, Canada, as well as Oil Sands, Ltd., Edmonton, Alta.

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Fig. 1—(Above) Typical flow of vapors and liquid in conventional bubble tower, showing how each flow may channel with resulting low efficiency of fractionation

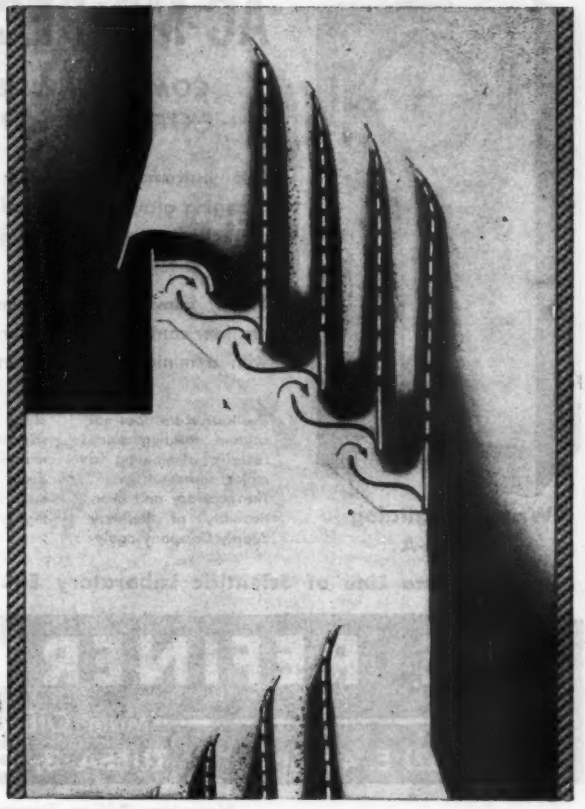


Fig. 2—(Right) Typical flow of vapor and liquid in Kaskade tray, showing uniformity and efficiency of fractionation

CASCADE-TYPE TRAY

Introduces New Fractionating Principle

by H. Litwin*

A NEW principle of fractionation has been introduced by the development of the cascade type of vapor-liquid contact tray described in this article. Vapor and liquid are brought together under uniform conditions in a series of cascades and are separated by centrifugal force. Capacities of existing towers are increased greatly by replacement of bubble trays with the cascade (Kaskade) type, one tower showing more than 100 per cent capacity increase. Data given show that this new tray has 36 per cent greater capacity, and 25 per cent greater efficiency than bubble trays of the same diameter.

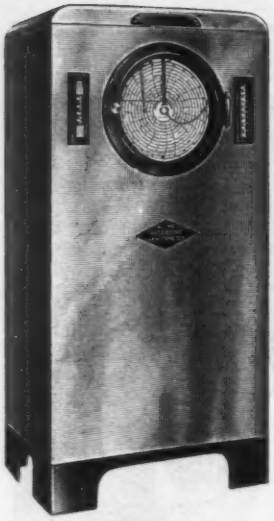
IT was only under the stress of war conditions that a really concerted attempt was made to delve into the operation of bubble-tray towers, that is, to attempt to see what was actually occurring inside the steel curtain. This research showed that no existing formulas adequately took into account all the factors entering into the determination of efficiency and capacity.

It became apparent that liquid-handling capacity rather than vapor-handling capacity was in most cases the limiting factor in determining over-all tower capacity. Moreover, although usual engineering practice limits the velocity of liquid over the weir, through and under the downspout, no formulas yet devised determine accurately the resistance to liquid flow across the tray, although a good effort has been made.[1] The problem is further complicated by the lack of knowledge of the actual density of the liquid flowing across the tray and through the downpour.

Some improvements have been made in recent years with the view of decreasing the resistance to liquid flow across the tray by eliminating certain obstructions such as cap-holding-down devices in the path of the liquid. Further improvement has been made by employing multipass designs for the larger towers which not only shorten the liquid path but provide additional weir length and better utilization of downpour area. However, the increased liquid capacity is not obtained without cost since with a multiple-pass tray the area available for bubble caps is reduced, the possibility of unequal liquid flows through the several passes is introduced and the complications of design and fabrication cost are increased.

In spite of these improvements which have measurably increased ca-

*The Koch Engineering Co., Inc.



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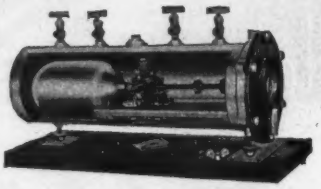

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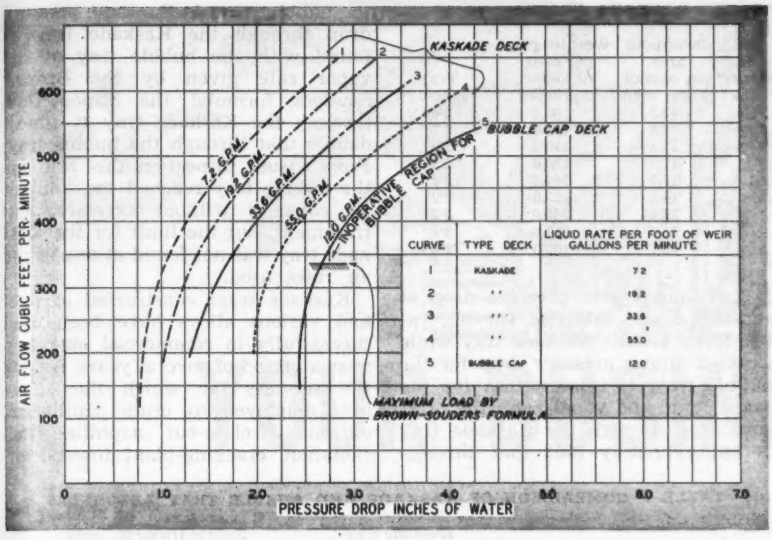

Fig. 3—Comparison of pressure drop through Kaskade and bubble tray

pacities, the bubble tray retains several fundamental weaknesses:

1. The total area of a bubble tray to be divided among caps, disengaging space, and downpour obviously is fixed. If one of these characteristics is increased it is only at the expense of the others, and oftentimes disengaging space is the one that suffers due to the tendency to crowd as many caps as possible on the tray.

2. Space is taken up and pressure drop is increased by necessity of vapor-flow reversal up the riser and back down through the annular space between riser and cap.

3. The contact between vapor and liquid is limited principally to that taking place as the vapor passes through the slots in the caps with very little further contact occurring before the vapor passes to the next tray above.

4. Regardless of design, the treatment given vapor and liquid across the tray is not uniform since:

(a) The composition of the liquid varies across the tray.

(b) The quantity of liquid passing along each cap and the length of liquid travel is not uniform across the tray.

(c) A liquid gradient is built up from the inlet to outlet side of the tray so that the head to be overcome by the vapors is not uniform. This allows a greater quantity of vapor to pass through the caps on the outlet than on the inlet side. As the liquid load increases the gradient increases until no vapor flows through the caps on the inlet side of the tray. Since all the vapor must flow through the caps on the outlet side the velocity increases with resulting increase in pressure drop and entrainment. With no vapor flowing through some of the caps this permits liquid to flow down the risers without contacting the vapors as illustrated in Fig. 1. In addition, the vapor velocity is so high through the few operating caps that the liquid is blown or "coned" with resulting extremely poor contact and excessive entrainment. As the load increases still further the pressure drop increases very rapidly until it exceeds the available head in the downpour and the tower surges, floods and "pukes." This liquid buildup is of course greatly accentuated in the larger tower sizes, so that a 12-ft. diameter tray will not handle four times the load of a 6-ft. diameter tray.

A large amount of experimental work has been carried out by Koch Engineering Co. over a period of several years on fractionating apparatus with the view of increasing capacity, improving efficiency, and in general eliminating the limitations and drawbacks of the conventional bubble tray. The design which was finally evolved, called the Koch Kaskade tray, is shown in principle in Fig. 2. In this fractionating apparatus liquid entering through a downpour from the tray above is fed into one of the parallel vapor streams entering from the tray below and the resulting mixture is hurled violently against a solid plate to which is attached a perforated baffle. The velocity of the mixture creates considerable centrifugal force as the mixture flows along and up the baffle, forcing all of the liquid and a portion of the vapor through the perforations. As the load increases the froth is thrown higher along the face of the baffle.

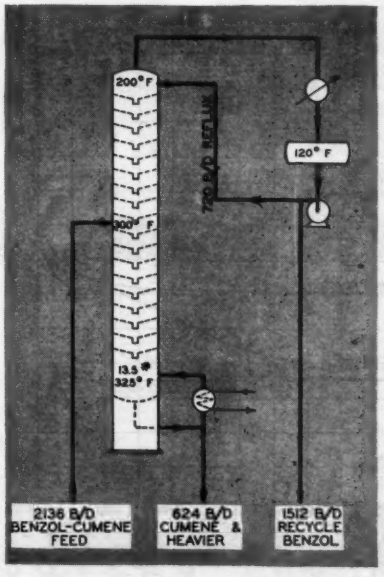

Fig. 4—Flow chart of benzol-cumene stripper

The liquid separates from the vapor on the other face of the baffle in a vigorous bubbling action and flows down the baffle to feed into the next trough where the operation is repeated. As the liquid passes through the last perforated baffle it drops into a downpour to be fed into the tray below. A major portion of the vapor passes upward along the near side of the baffle and is deflected by the backwardly curved edge at the top to knock down any entrainment. Due to the stair-step arrangement of troughs there is no chance for liquid buildup, so that very large quantities of liquid can be handled. Moreover, since all the liquid passes into each trough successively, all the liquid receives the same treatment.

Due to the violence of vapor-liquid mixing the liquid is broken up into very fine droplets so that high fractionating efficiency is obtained even with cold and relatively viscous oils such as found in absorbers. Furthermore a large contacting surface is provided by the perforated baffles.

Fundamentally the Kaskade tray action is that of vapor-liquid mixing and then separation by mechanical means, namely centrifugal force, which provides many times the vapor-liquid separating force available in a bubble tray depending for separation only on the simple difference in density between vapor and liquid.

For further description of the principles involved in the design and operation of the Kaskade tray the patent[3] may be consulted.

Fig. 2 illustrates a single contacting unit applicable to the smaller sizes of towers. For towers 3 ft. in diameter and larger a tray contains two or more cascading units, each consisting of several troughs welded into a rectangular housing which forms a section, with removable baffles fastened to the front of each trough. To each section is attached also a rectangular downpour extending the full length of the unit. The several sections are supported on a flat plate

TABLE 1—DIMENSIONS OF TYPICAL KASKADE TRAYS

Tower diameter	No. of cascading sections	Troughs per section	Riser area, per cent of tower area	Downpour area, per cent of tower area	Weir length, per cent of tower diameter	Tray spacing
2'6"	1	6	17.7	17.9	80.0	2'6"
3'0"	2	3	12.5	17.4	135.0	2'2"
3'6"	2	4	14.8	17.4	140.0	2'2"
4'0"	2	5	16.1	17.0	138.0	2'6"
5'0"	4	3	12.5	19.7	224.0	2'2"
5'6"	4	3	11.9	18.1	235.0	2'2"
6'0"	4	3	12.4	18.8	265.0	2'2"
8'6"	8	4	14.0	16.0	321.0	2'4"
10'0"	10	4	14.5	16.7	400.0	2'4"

welded to the tower shell, the plate serving also to redistribute the liquid entering from the downpours of the tray above. The number of troughs in each cascading unit can be varied readily to suit particular requirements of vapor and liquid areas and desired degree of contacting. The sections are designed so that they can be inserted or removed readily through an ordinary manway.

With the Kaskade design greater vapor areas, downpour areas, and weir lengths are provided concurrently than can be obtained in the bubble tray. By way of illustration these characteristics are listed in Table 1 for commercial trays now in operation although it is to be noted that the proportions can be varied widely.

With the elimination of practically all liquid head to be overcome by the vapors plus provision of ample vapor and liquid passages, the pressure drop through the Kaskade tray is appreciably less than that through the bubble tray operating under the same vapor and liquid loads. Fig. 3 shows the results of one series of tests in which a laboratory model Kaskade tray with 10-in. weir containing four troughs was compared with a bubble tray of the same diameter containing three 6-in. bubble caps, using air and water as the contacting fluids. Curves 1, 2, 3, and 4 give pressure drop at constant liquid rate and varying vapor flows for the Kaskade tray while Curve 5 shows pressure drop for the bubble tray. It is seen that for the same liquid and vapor rates the pressure drop through the Kaskade tray is approximately half that through the bubble tray. At the same pressure drop through the Kaskade tray as found with the bubble tray at the vapor rate given by the Brown-Souders formula[1] the vapor flow through the Kaskade tray is almost double that through the bubble tray. From visual inspection this rate for the bubble tray reached the limit of its capacity without excessive entrainment, but the limit for the Kaskade tray was not found at any of the air rates used.

Kaskade trays constructed of steel and various alloys have been used successfully in commercial operation over a period of several years. Among the services for which they have been employed are crude distillation, extremely close-cut naphtha fractionation, cracking-plant towers, absorbers, recovery and stabilization units, etc.

TABLE 2—COMPARISON OF KASKADE AND BUBBLE TRAY ABSORBERS

	Kaskade tray	Bubble tray
Diameter, ft.	6	7
No. absorption trays	16	20
Residue gas vol., st. cu. ft./day	27,800,000	27,600,000
Oil rate, g.p.d.	314,500	308,500
Pressure, psig.	51.5	51.5
Lean-oil temp., °F.	69	69
Rich-oil temp., °F.	90	90
Lean-oil gravity, °A.P.I.	41.0	41.0

Pod. analyses—	Inlet gas mol. vol. %	Residue gas mol. vol.%	Inlet gas mol. vol. %	Residue gas mol. vol. %	Lean oil mol. vol. % / liq. vol. %
Nitrogen	....	.84	1.13	.91	....
Oxygen	....	.14	.13	.13	....
Methane	81.41	82.78	79.76	82.42	....
Ethane	10.63	10.47	10.84	10.14	....
Propane	4.60	4.18	4.76	4.47	....
Isobutane	.70	.37	.48	.32	....
n-Butane	1.37	1.19	1.64	1.30	....
Isopentane	.35	.15	.29	.11	.11 / .09
n-Pentane	.45	09	.49	.11	.44 / .37
Hexanes	.12	.05	.28	.09	.60 / .57
Heptanes+	.37	.04	.20	....	98.85 / 98.97
Total	100.00	100.00	100.00	100.00	100.00

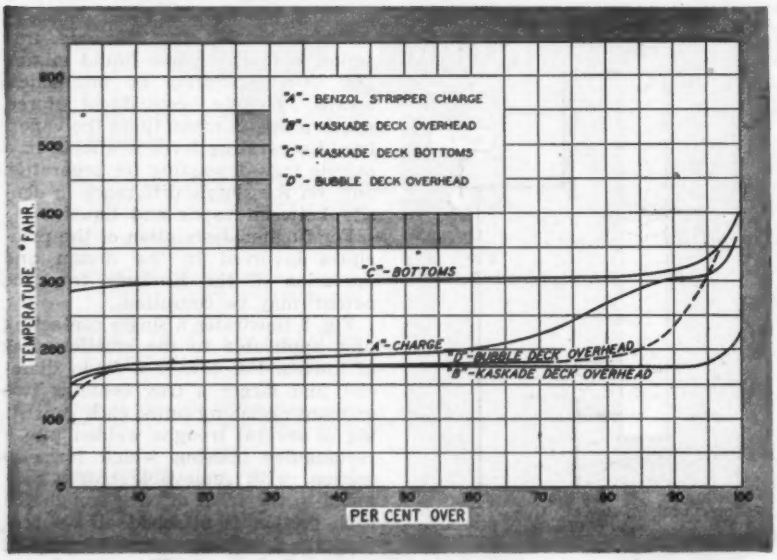

Fig. 5—Distillation curves for benzol-cumene stripper

In several instances Kaskade trays replaced trays in existing towers which had been considerably overloaded. No difficulty was experienced in making the conversion and in each case the Kaskade trays in operation carried the load easily and smoothly and performed a better fractionating job than the conventional trays had done.

One interesting replacement job was that of a benzol-cumene stripping tower on a catalytic polymerization unit in which the original 4-ft. diameter bubble tray was overloaded at a charge rate of approximately 2,000 bbl. per day. After replacement with 4-ft. diameter Kaskade trays the limiting capacity was not reached at a charge rate of approximately 4,000 bbl. per day. The operating conditions for the Kaskade trays shortly after they were put into service in November 1943 are shown in Fig. 4. The distillation curves of

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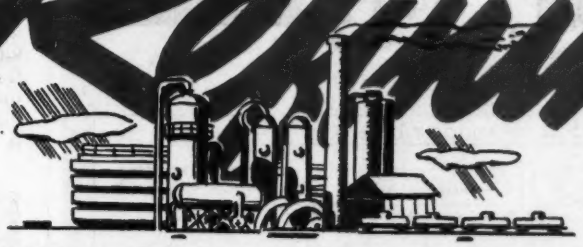

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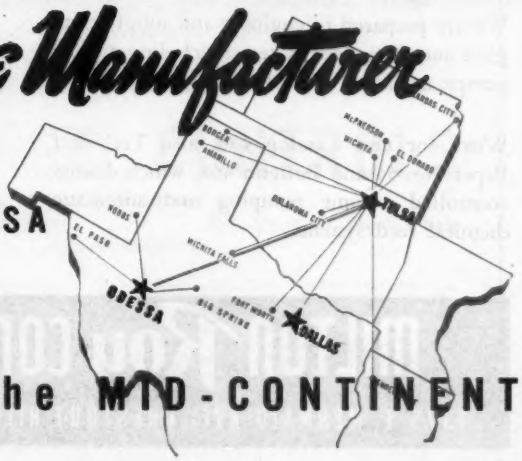

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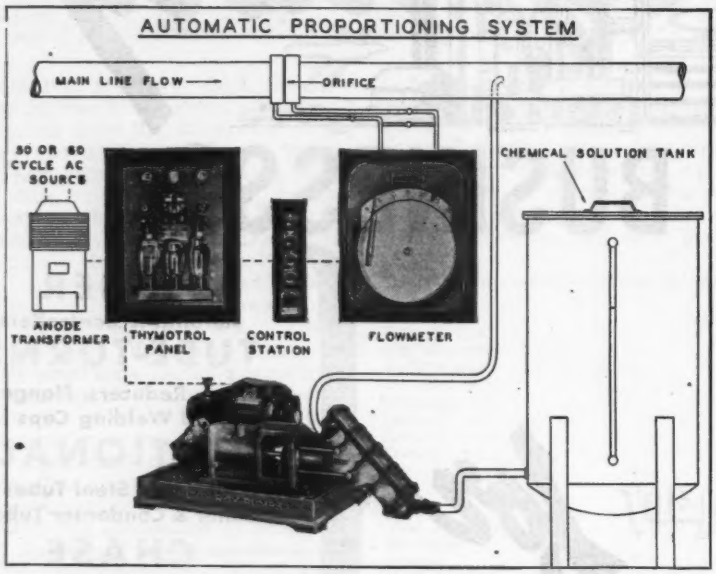

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the charge and products obtained with the Kaskade trays under these conditions compared to results obtained with the old bubble trays under the same conditions are shown in Fig. 5.

Another comparison between Kaskade and bubble decks was obtained from commercial operation in a natural gasoline plant where a 6-ft. diameter, 16-Kaskade-tray absorber is operated in parallel with a 7-ft.

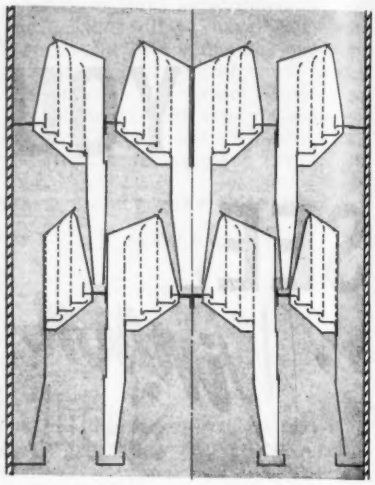

Fig. 6—Arrangement of multiple Kaskade trays in tower, illustrating down-flow connections between levels

diameter, 20-bubble-tray absorber. When these absorbers are operated at approximately their maximum capacity without excessive entrainment the load carried by each tower is the same. The operating conditions and gas analyses are given in Table 2 for one test. These figures show that the Kaskade tray capacity is 36 per cent greater than that of the bubble tray and the tray efficiency approximately 25 per cent greater, based on substantially the same gasoline recovery with both towers.

Conclusions

The Koch Kaskade tray as a radically different device for vapor-liquid contacting and fractionation has the following advantages over the conventional bubble tray:

1. It has approximately 50 per cent greater vapor and liquid capacity.
2. It is less subject to surging and flooding at varied loads.
3. Its pressure drop is less for the same throughput.
4. It has better efficiency.

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2. Koch, F. C., U. S. Patent 2,401,569, Apparatus for Effecting Intimate Contact Between Gases and Liquids, June 4 (1946).
3. Souders, M., and Brown, G. G., Ind. Eng. Chem. 26, 98 (1934).

1947 Refining Developments

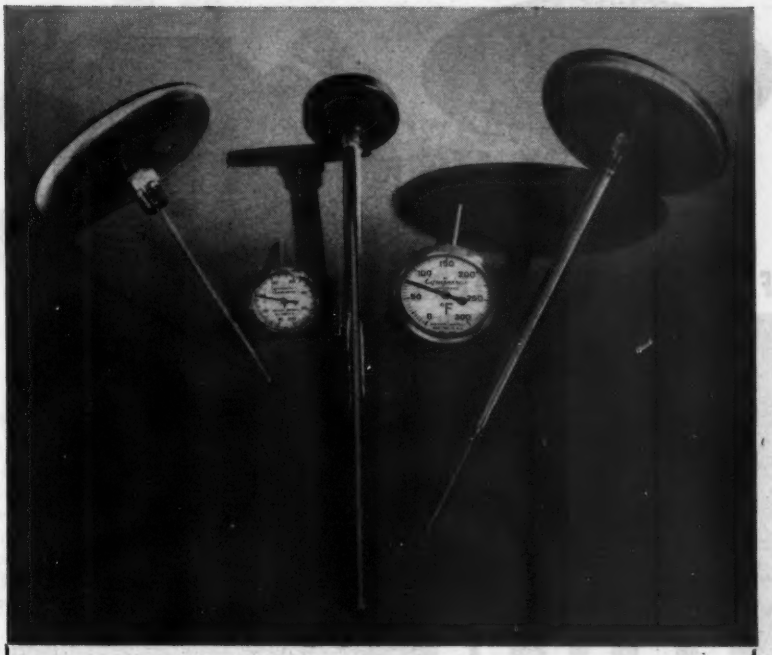
(Continued from page 193)

the octane-rating improvement in thermal gasolines is in the formation of large percentages of olefins, especially in the lower-boiling range of the fuel. Thermally cracked gasoline shows good antiknock properties at low speeds with less improvement at high speeds. While catalytic gasoline has considerable quantities of olefins also, it is much higher in isoparaffins, naphthenes, and aromatics than is thermal gasoline. Catalytic gasoline also carries its high antiknock properties into the higher-boiling range of the fuel, and increases efficiency of high-speed operation; it raises the total yield of gasoline possible, since it is possible to run to higher end points without reducing octane rating of the fuel below competitive levels, while thermal gasoline must be cut at 400°-410° F. to avoid inclusion of the low-grade heavy ends. Inclusion of the heavier fractions also tends to raise yields over-all since a correspondingly greater amount of light ends theoretically may be included to balance the low volatility of the heavy material.

Therefore the trend in automotive-engine design is toward changes which enable the engine to take advantage of the blends of fuels of both types and to utilize fuels which have high antiknock quality throughout their boiling ranges. Trend now seems to be toward the valve-in-head type of engine, typified by the Chevrolet and Buick engines, rather than to the more common L-head motor, since these engines are claimed to operate better on a given octane rating, or to give a satisfactory performance on lower octane numbers than do L-head engines of the same ratios.

Because of the complementary nature of the two types of cracked gasoline components, mentioned above, and because the thermal cracking unit can process recycle oil from the catalytic somewhat more profitably than the catalytic unit can crack the same material, the thermal cracking unit is far from passing out of the refining picture. The thermal cracker can operate in conjunction with the catalytic cracker as indicated, each supplementing the other to manufacture a more balanced motor fuel with higher over-all yields, we are told.

An added impetus is given also, recently, to catalytic polymerization of otherwise waste unsaturated refinery light fractions by the need for higher yields and higher octane ratings. Operation of selective polymerization in both so-called phosphoric acid and phosphate catalyzed processes especially during the war and



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later has aided in improvement of the processes in vital details. Catalysts have been improved until 120-150 gal. of polymer of gasoline range is obtained per pound of catalyst before the latter is spent. The development of the process for dehydration of new catalyst before its introduction into the process has sped up the bringing of the unit on stream, after refilling with new catalyst, by 24-48 hours it is understood, reducing the time the unit is off stream and increasing its over-all efficiency.

Trends in yields and demand for products appear to be moving inevitably in the direction of more middle-fraction oils such as distillate fuels, diesel fuels, furnace oils, and similar products. If this trend is real, the use of catalytic cracking processes gives the refiner a definite advantage, since recycle oils and catalytically cracked gas oil materials are superior to those obtained from thermal cracking. Catalytic processes permit the refiner also to reduce materially his yield of heavy residual fuel oil and to sell more of his barrel of crude at higher prices, according to authorities in this field. As road-building programs get more under way the demands for road oils and asphaltic products will increase considerably, it is expected.

Technical developments in synthetic-petroleum operations received strong impetus during 1946 and one large unit—6,000 bbl. of gasoline, etc., per day—is planned by Stanolind Oil & Gas Co. and associates for western Kansas to start construction during 1947, it is understood. Another unit of about the same output capacity is well under way in southern Texas by Carthage Hydrocol, Inc., using a process developed by Hydrocarbon Research, Inc., and employing the Fischer-Tropsch principles with Fluid-type catalyst. Using an iron catalyst less active than the cobalt catalyst of the Germans, but far more rugged and long lived and yielding a much more desirable, high-octane-number gasoline, American practice shows about 65 per cent liquid yield based on the carbon in the gas charged, of which 83 per cent is 10 lb. R.v.p. gasoline of 80 A.S.T.M. octane number, 89 research rating and about 87 road octane number. Some 10 per cent is 45-50 cetane-number diesel fuel, 7-8 per cent heavy oils high in paraffin-wax content, it is reported. The olefin content of the gasoline and lighter hydrocarbons is said to be high.

Diesel fuel of 100 cetane number can be made by varying the conditions but the yields and properties of other products are changed undesirably. Costs are estimated to be 5 cents per gallon of gasoline with gas at 5 cents per thousand cubic feet. Investment is estimated at $3,000-$3,500 per barrel of output.

ELECTRONICS Aids Progress In Refinery Instrumentation

by Douglas M. Considine *

INSTRUMENTATION and petroleum processing have come a long way together over the past decade. The petroleum industry, through an early appreciation of the need for instruments and controls and through the pioneering of engineering methods for efficiently applying these tools to laboratory, development, and manufacturing operations, has done much to catalyze the progress in instrument design. In this article, some of the more recent designs and techniques of instrumentation, several of which are the result of specific requirements of the petroleum industry, are described.

NUMEROUS important improvements have been made in control and recording instruments for use in refining operations by the introduction of electronics principles into instrument making. These new ideas increase speed of recording and control operations, low lag in measurements, make for greater ruggedness of instruments, assure longer life and lower maintenance. Ultraviolet and infrared spectrometers and X-ray spectrometer are becoming increasingly important in research. The use of electronic units in the potentiometer has improved its performance remarkably. This article shows how these new principles have been applied to many instrument assemblies.

Electronic Methods

Undoubtedly, one of the greatest advancements to come out of the instrument industry in a score or more years is the potentiometer based upon electronic rebalancing means rather than upon mechanical means. The rapid relegation of the mechanical (galvanometer) type potentiometer to a past era has been the result of several outstanding advantages of the electronic type, including: (1) higher indicating and recording speeds, down to a very few seconds across full scale, (2) low measuring lag, which greatly contributes to the quality of automatic control obtainable, (3) physical sturdiness and ruggedness, including a practical immunity to vibration and position, and (4) longer life with less maintenance required, due principally to the use of fewer mechanical moving parts.

These factors have become well known during the past 5 years, that is, since the introduction of the first instruments of this type designed especially for industrial service at a cost commensurate with such service. This development in potentiometer design is of such great importance, not only since improvements in temperature measurement are made possible, but because the detection of other variables such as pH, high vacuums, chemical composition, force (strain) also enjoy equally the advantages of the electronic potentiometer.

*The Brown Instrument Co., Philadelphia.

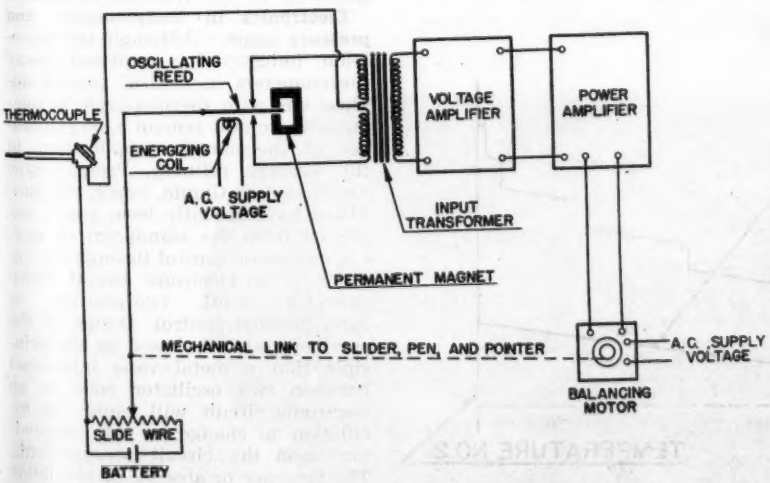


Fig. 1—Schematic diagram of electric potentiometer. (Courtesy Brown Instrument Co.)

Potentiometer circuit. — The basic circuit of one type of electronic potentiometer is illustrated in Fig. 1. Note that the conventional cyclic rebalancing mechanism has been replaced with a motor which continuously rebalances the indicating and recording system to correspond to changes in the measured variable. Briefly, the direct current millivoltage created by the thermocouple is changed to an alternating current voltage of proportional magnitude in a converter. The converter essentially is a flat metal reed oscillating between two contacts connected to the opposite ends of the primary winding of an input transformer. The unbalanced direct-current voltage is impressed across the converter and the center tap of the primary winding of the input transformer. As the reed moves from one contact to the other, any unbalanced direct current voltage will cause direct current to flow first in one direction through one-half the primary winding, then in the opposite direction through the other half. This action generates an alternating flux in the input-transformer core which, in turn, induces an alternating voltage on the transformer secondary.

The action of the converter is related to the alternating-current-supply voltage by the energizing coil which is excited by the alternating-current-supply voltage through a stepdown transformer. The reed is polarized by a permanent magnet and, therefore, is actuated by the energizing coil to oscillate in synchronism with the alternating current supply voltage. The reed closes one contact to the transformer for one-half the supply voltage cycle and the other contact for the other half, making one complete oscillation for each cycle. The direct current flowing in each half of the transformer primary winding, therefore, will create an alternating voltage in the transformer

secondary of the same frequency as the supply voltage. This alternating voltage is amplified in voltage and power to where it will actuate a two-phase balancing motor.

If there is an unbalance between the slide-wire voltage and the thermocouple voltage, the balancing motor functions to rebalance the two voltages by moving the slider on the slide wire. The direction in which the motor turns is determined by a definite phase relationship between the alternating-current-supply voltage and the amplified alternating-current thermocouple voltage. This relationship depends, of course, upon whether the measured variable is increasing or decreasing in magnitude.

Advantages to automatic control.—The employment of electronic principles in the potentiometer has reduced measuring lag to such an extent that closeness of control never before obtained with any form of industrial controller is now routine. Where as many as 24 seconds were formerly required for a pneumatic controller to respond completely to a change in temperature, the electronic-type potentiometer with proportional-plus-reset control responds completely in about 2 seconds. In general, it can be stated that the electronic potentiometer has detected the change in temperature and has made a suitable correction in the control valve setting before the galvanometer-type potentiometer has recognized the fact that any change in temperature has occurred.

Such response obviously permits the use of much narrower throttling ranges (proportional bands) with consequent greater hold on the process and closer over-all control. Similar characteristics are noted on electric contact controllers, where the amplitude of the temperature cycle may be reduced to one-fifth that produced by the conventional instrument.

In sharp contrast, the periodic (galvanometer) type instrument must wait about 2½ seconds before any change is detected, after which the required correction is made in a series of slow step-like movements. Meanwhile, the temperature continues to deviate from the desired control point. The comparative response of one type electronic potentiometer and a periodic-type instrument is illustrated in Fig. 2. When a change in controlled variable on the order of 0.2 per cent of scale span takes place, which is quite normal in the close control of fractionating columns, the electronic instrument responds and institutes control action within ½ second, while the periodic instrument does nothing about it for approximately 2½ seconds. A complete correction is made by the electronic instrument in 2 seconds, while the periodic instrument requires 24 seconds.

Although the sensitivity of the galvanometer-type instrument is limited by the fundamental considerations of galvanometer design, much higher sensitivity can be obtained in the electronic potentiometer through the use of several stages of electronic amplification. In one standard instrument, three stages of amplification are used to obtain a sensitivity on the order of 0.1° F. which is almost eight times the sensitivity possible with galvanometer-type instruments.

The comparative balancing actions of multiple recorders of the electronic and periodic types are shown in Fig. 3. Note that the faster recording cycle on the electronic instrument is due to the continuous motion of the print carriage from point to point. The characteristically intermittent step-like motion of the print carriage of the periodic types is also shown. These steps, as shown graphically, are required to permit the galvanometer to assume a new deflection corresponding to the residual unbalance.

Electronics in thermometers and pressure gages.—Although the petroleum industry has replaced many thermometers in critical control applications with thermocouple pyrometers, there still remain a large number of thermometer applications in the average refinery. Pressure-type thermometers (liquid, vapor, and gas-filled) have recently been vastly improved from the standpoint of electric automatic control through the addition of an electronic circuit which provides on-off, two-position, or three-position control. Design of the new controllers is based on the principle that a metal vane interposed between two oscillator coils in an electronic circuit will cause the oscillation to change or stop, depending upon the circuit arrangements. The presence or absence of oscillation

(Continued on page 255)

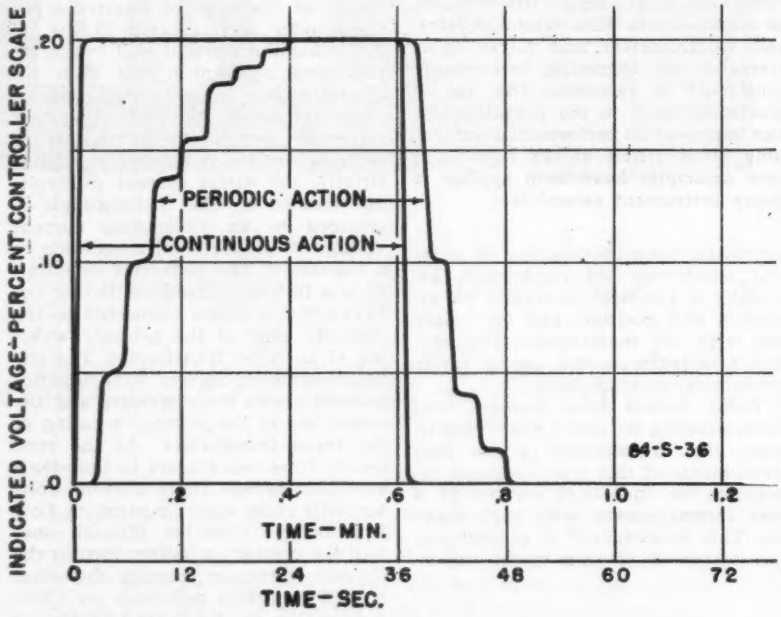


Fig. 2

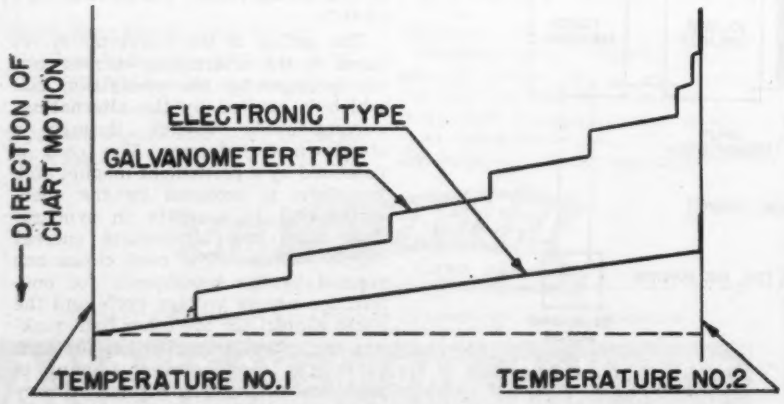


Fig. 3

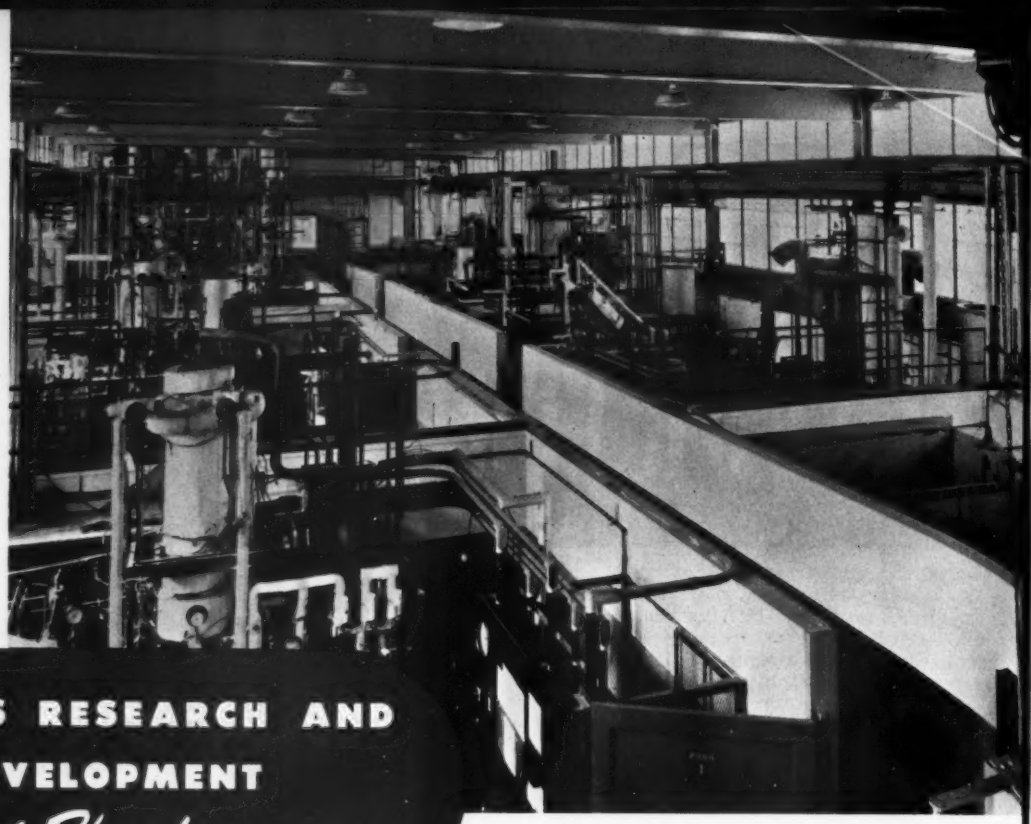
HOUDRY LABORATORIES

First and Foremost in Catalytic Cracking

Houdry was *first* to make catalytic cracking commercially practicable—pioneered its development nearly a quarter-century ago.

Houdry remains *foremost* in catalytic research—for there is more catalytic "know-how" in Houdry Laboratories than can be found in any similar scientific organization, regardless of size or sponsorship.

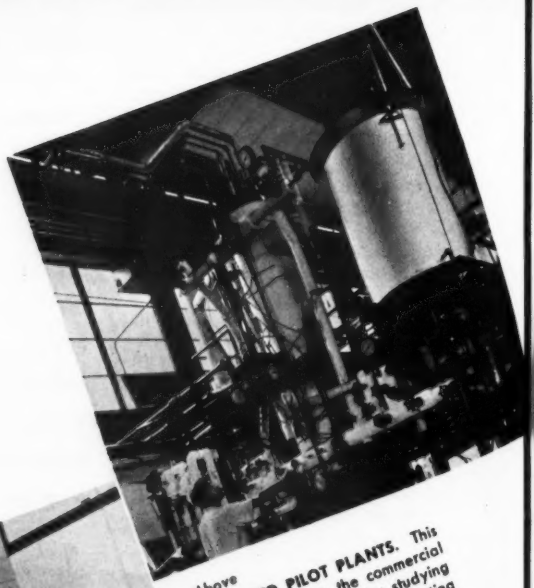
Located near Marcus Hook, Pa., Houdry Laboratories are among the most modern, best equipped, most ably staffed laboratories in the world. From their hundreds of top-flight chemists, chemical engineers, mechanical engineers, technicians and specialists in refinery operation, flows a priceless stream of discovery, contributing enormously to the success of Houdry licensees, to the progress of the petroleum industry and to the welfare of society.



DEVELOPMENT LABORATORIES. A general view showing some of the many pilot plants which are necessary for developing catalytic processes and for providing accurate information for Houdry licensees.

PROCESS RESEARCH AND DEVELOPMENT *at Houdry*

Above
FUNDAMENTAL RESEARCH. Transforming C^{13} from heavy methane gas to barium carbonate, in which form it is used by biological laboratories for metabolism studies.



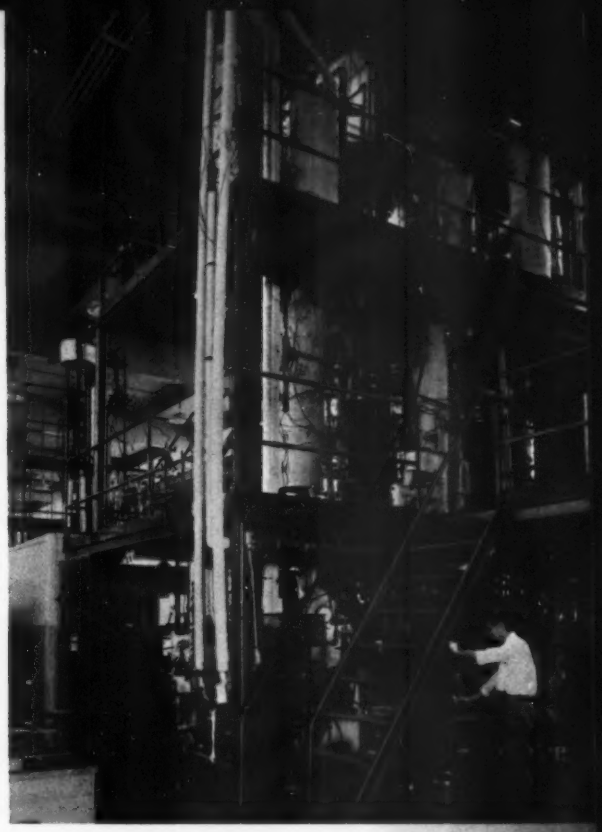
Above
FIXED-BED PILOT PLANTS. This reactor simulates the commercial design and is used for studying operating variables or evaluating proposed commercial charging stocks. Pilot plant process data duplicate exactly yields from commercial plant operation.

Left
PROCESS RESEARCH. Studies are carried out on small scale to provide basic data for process evaluation and larger scale work.

PROCESS research at Houdry is directed toward the finding of new reactions which may improve refining methods and conserve material resources. Hundreds of possibilities are investigated by research groups on a small scale. Those having promise are turned over to development groups for pilot-plant experimentation.

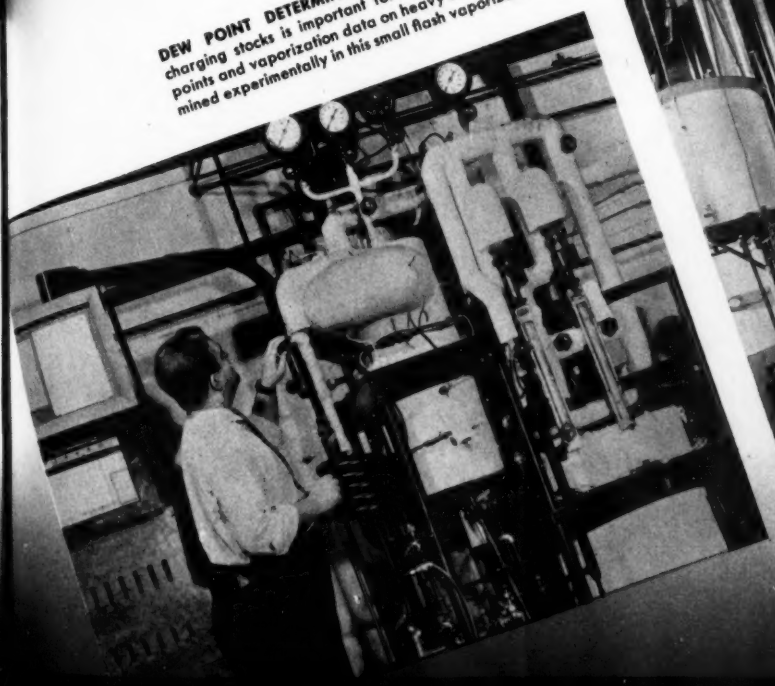
In process development, pilot plants are constructed and operated to perform the desired reactions and models of proposed commercial designs are tested. Currently, the Houdry Process Development Laboratory operates 15 to 20 such units to determine, with utmost accuracy, results reproducible on a commercial scale. Complete facilities are available for T C C and Houdry fixed-bed catalytic cracking and treating, polymerization, dehydrogenation and desulfurization, as well as other catalytic and non-catalytic refining processes.

The separation of isotopes of carbon and other elements, and tracer studies involving these materials, are an interesting part of Houdry fundamental research which has commanded nation-wide attention. Two units for the separation of C^{13} are in operation and another for the separation of O^{18} is under way.

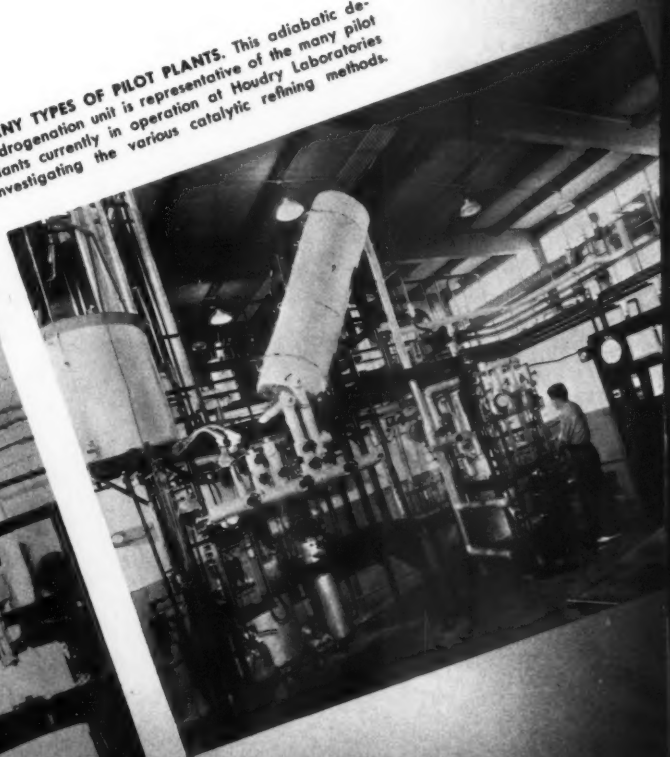


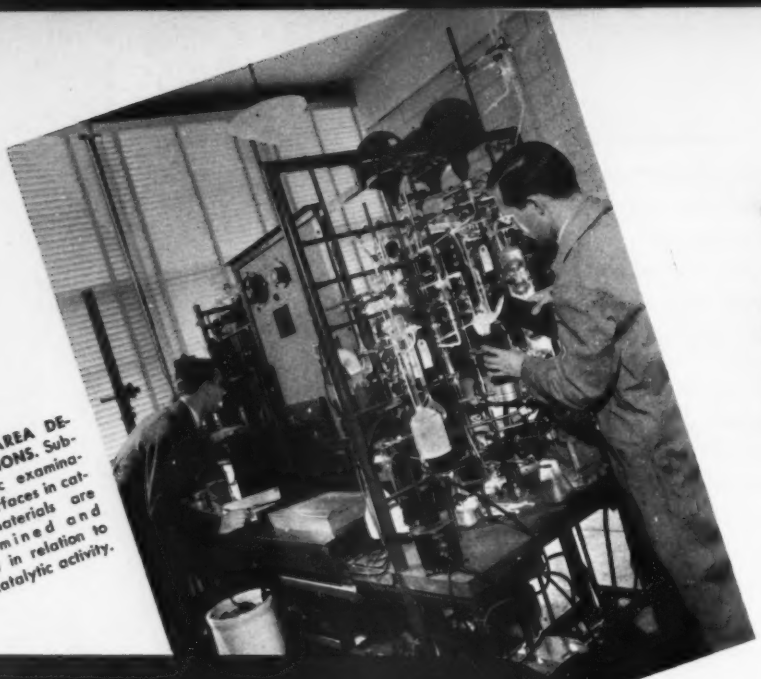
T C C PILOT PLANTS. These two units are used for the evaluation of charging stock and the development of new applications for the T C C process. Pilot plant data are in exact agreement with commercial T C C operation.

DEW POINT DETERMINATIONS. Physical data on charging stocks is important for evaluation work. Dew points and vaporization data on heavy stocks are determined experimentally in this small flash vaporization unit.



MANY TYPES OF PILOT PLANTS. This adiabatic dehydrogenation unit is representative of the many pilot plants currently in operation at Houdry Laboratories investigating the various catalytic refining methods.





SURFACE AREA DETERMINATIONS. Subtion of surfaces in catalytic materials are determined and studied in relation to their catalytic activity.

CATALYST RESEARCH AND DEVELOPMENT *at Houdry*

Below
CATALYST TESTING LABORATORY. The six miniature cracking cases shown are used to measure the activities of different catalysts. This activity test is used in catalyst research, for catalyst production control and for plant surveys.

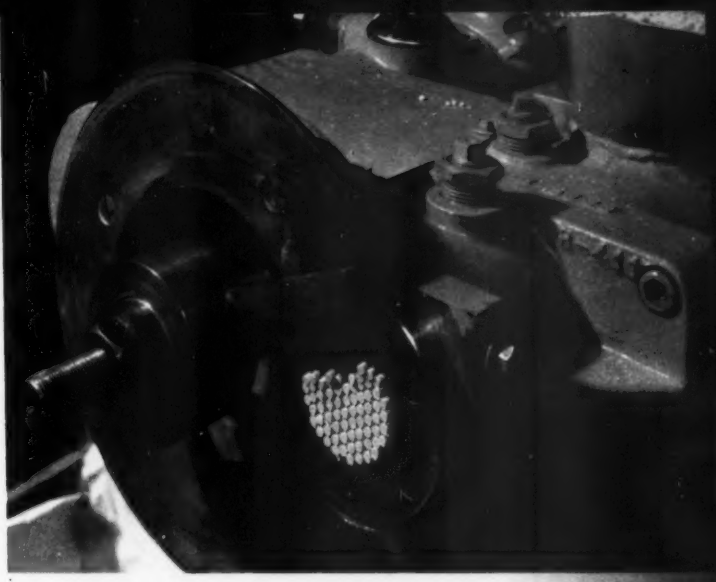
CATALYST PREPARATION. Intimate mixing, preliminary to pelleting, is an essential operation in the preparation of sound and active catalysts.

SPECIAL CATALYST ACTIVITY TEST HEAT TREATING UNIT. Rigid control of the conditions under which catalysts are prepared is constantly maintained.

HOUDRY was first to perfect, and produce commercially, natural catalysts for the catalytic cracking of petroleum. Similarly, Houdry was first to perfect and produce synthetic catalysts. Continuous research and development serve to maintain and enhance Houdry's leadership in the catalyst field and help Houdry licensees to keep abreast of major improvements in refining techniques.

Catalyst Research in Houdry Laboratories aims to improve catalysts used in existing commercial processes and to discover new catalysts for processes under development. Extensive study of physical and other characteristics of catalytic materials is made to determine the fundamental properties which impart catalyst activity. Information thus secured is applied to the development of new catalysts possessing improved characteristics.

Catalyst Development translates such knowledge from the research stage to the production stage, adapting the means and methods of small-scale experimentation to large-scale manufacture. Equipment in the Houdry catalyst development laboratory duplicates commercial conditions of mixing, grinding, drying, pelleting and other steps used in the volume production of catalyst.



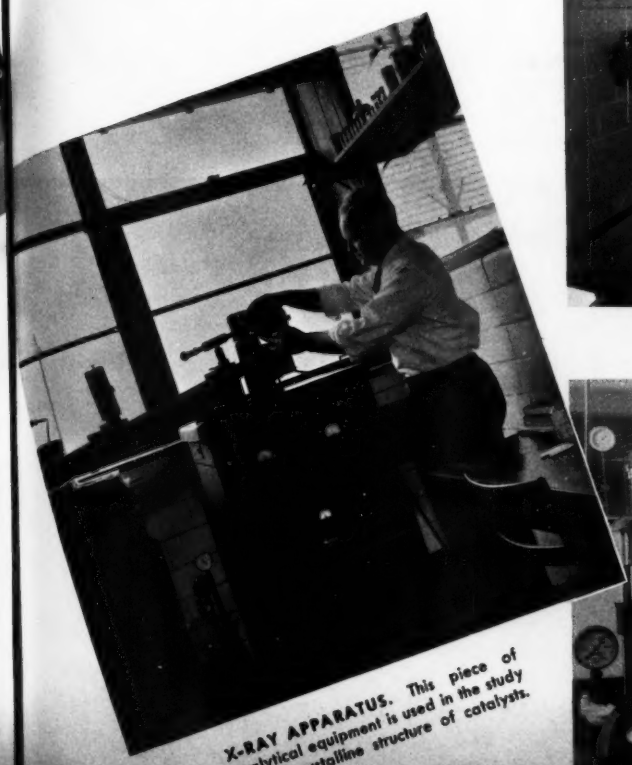
CATALYST EXTRUSION. Forming catalyst pellets in one of the modern specialized types of equipment available in the catalyst development laboratory.

Below

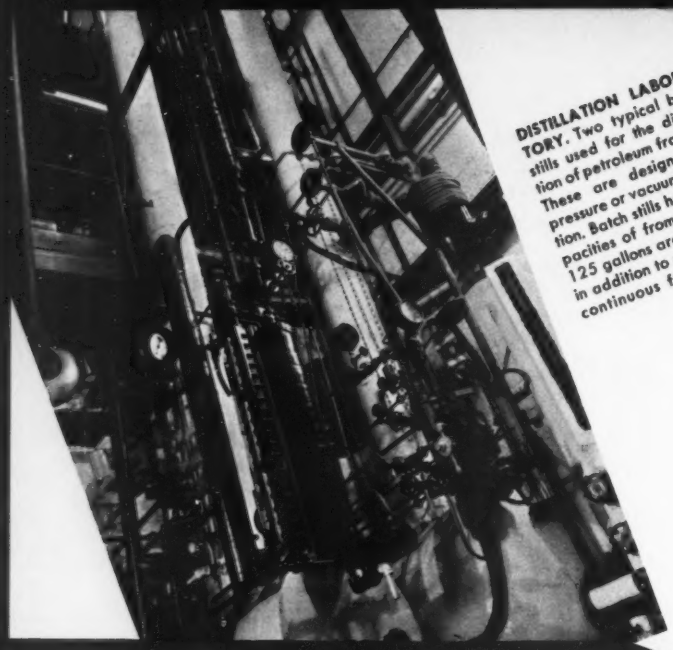
EMISSION SPECTROGRAPH. This specially designed analytical instrument is used for qualitative and quantitative analyses of metals in catalysts.

Bottom

DENSITOMETER. Spectrum obtained from the Emission Spectrograph is scanned and measured to complete the analysis of catalytic materials.



X-RAY APPARATUS. This piece of analytical equipment is used in the study of the crystalline structure of catalysts.



DISTILLATION LABORATORY. Two typical batch stills used for the distillation of petroleum fractions. These are designed for pressure or vacuum operation. Batch stills having capacities of from 10 cc. to 125 gallons are available in addition to an 18-plate continuous fractionator.

THE SERVICE LABORATORIES *at Houdry*

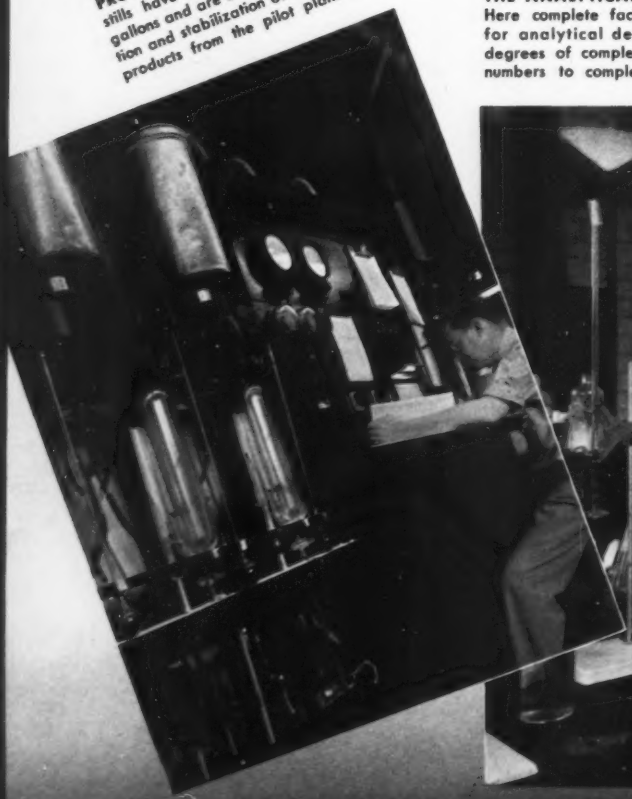
HOUDRY Service Laboratories perform almost innumerable tests and analyses to help Houdry licensees to secure optimum yields and maximum earnings. Their functions include catalyst analysis for composition and activity; catalyst testing; pilot-plant evaluation studies of potential charge stocks, with complete inspections of all catalytic products as to octane numbers, gravities, distillation, vapor pressures, pour points, aniline numbers, diesel index, viscosities, sulfurs, etc.

The most modern physio-chemical analytical methods are used, including a Mass Spectrometer, Emission Spectrograph, Ultra-Violet Spectrophotometer, and X-ray Diffraction machine.

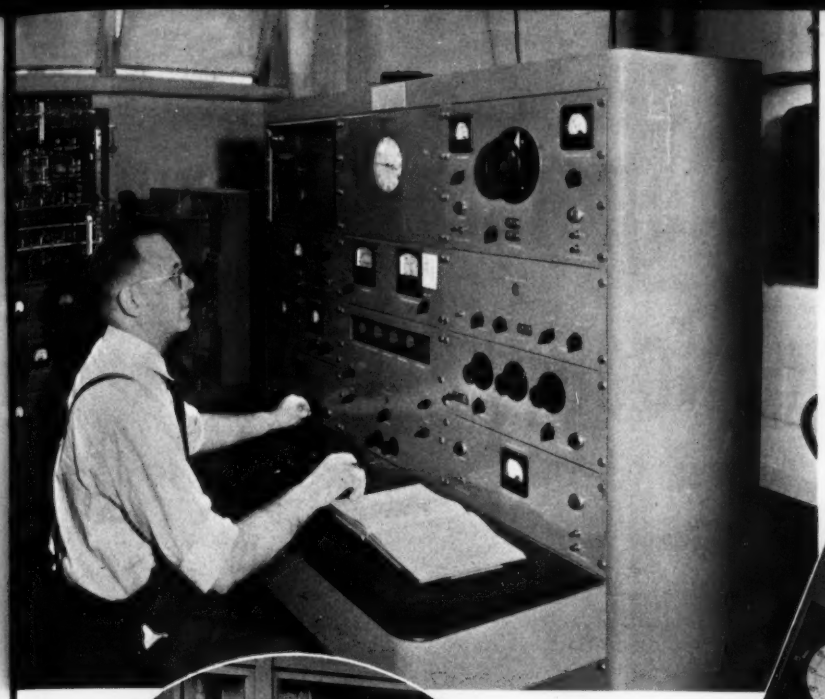
The petroleum testing laboratory has developed more than 50 different test procedures, some of which have been adopted as ASTM standards.

The catalyst testing laboratory predetermines the performance of catalyst—as to activity, stability and selectivity—with any submitted charging stock.

PRODUCT FRACTIONATION. These stills have capacity of about two gallons and are used for the separation and stabilization of the gasoline products from the pilot plant units.

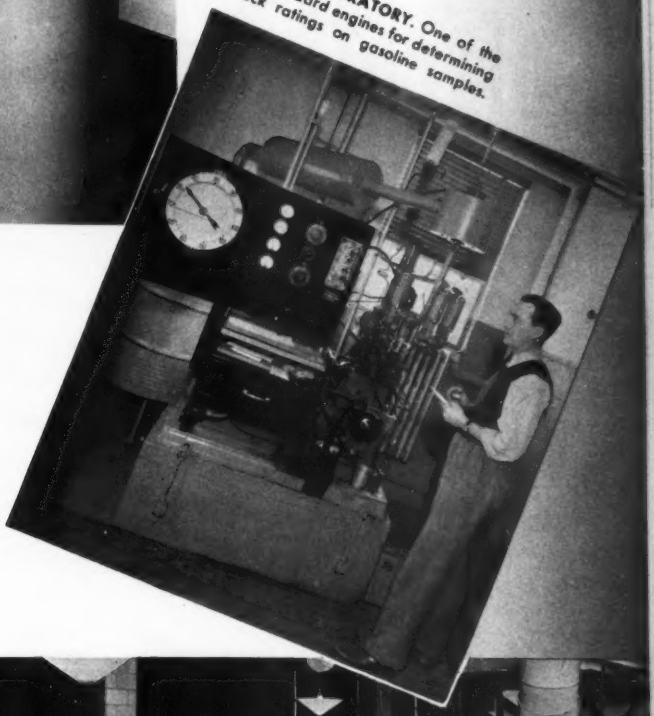


THE ANALYTICAL LABORATORIES. Here complete facilities are available for analytical determinations of all degrees of complexities from bromine numbers to complete silicate analyses.



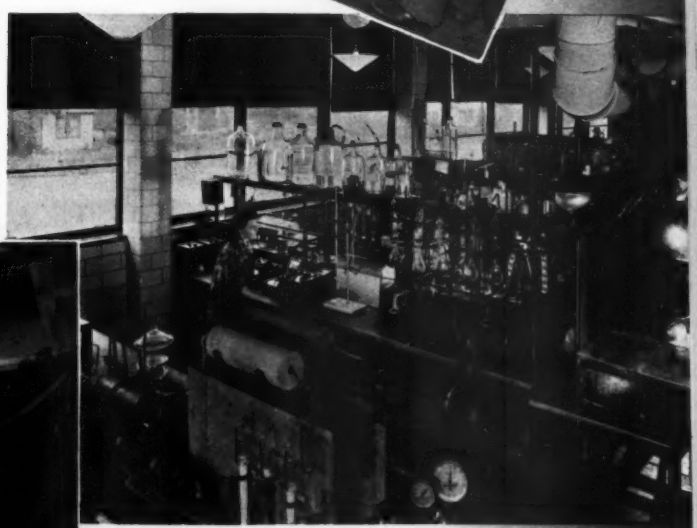
THE MASS SPECTROMETER is employed in the rapid and accurate determination of the composition of mixtures of light gaseous hydrocarbons.

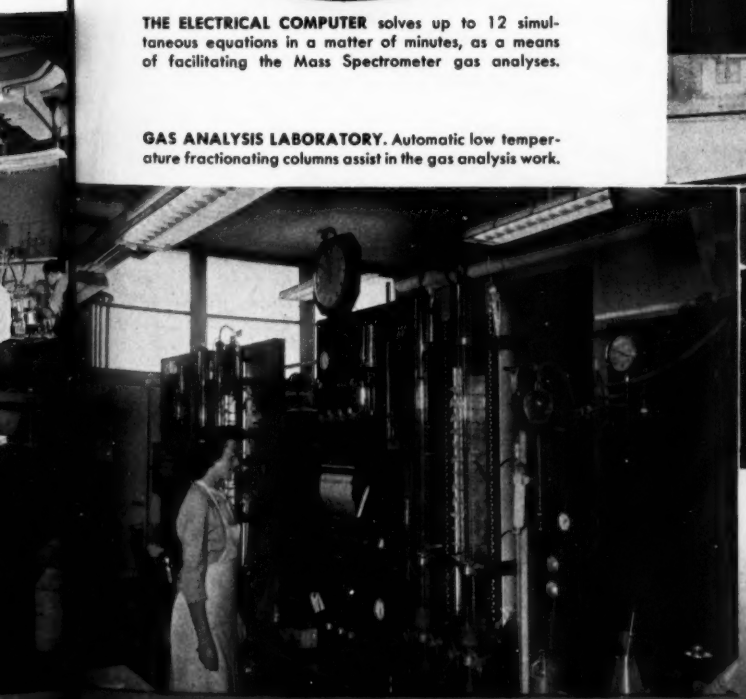
ENGINE LABORATORY. One of the four standard engines for determining knock ratings on gasoline samples.



THE ELECTRICAL COMPUTER solves up to 12 simultaneous equations in a matter of minutes, as a means of facilitating the Mass Spectrometer gas analyses.

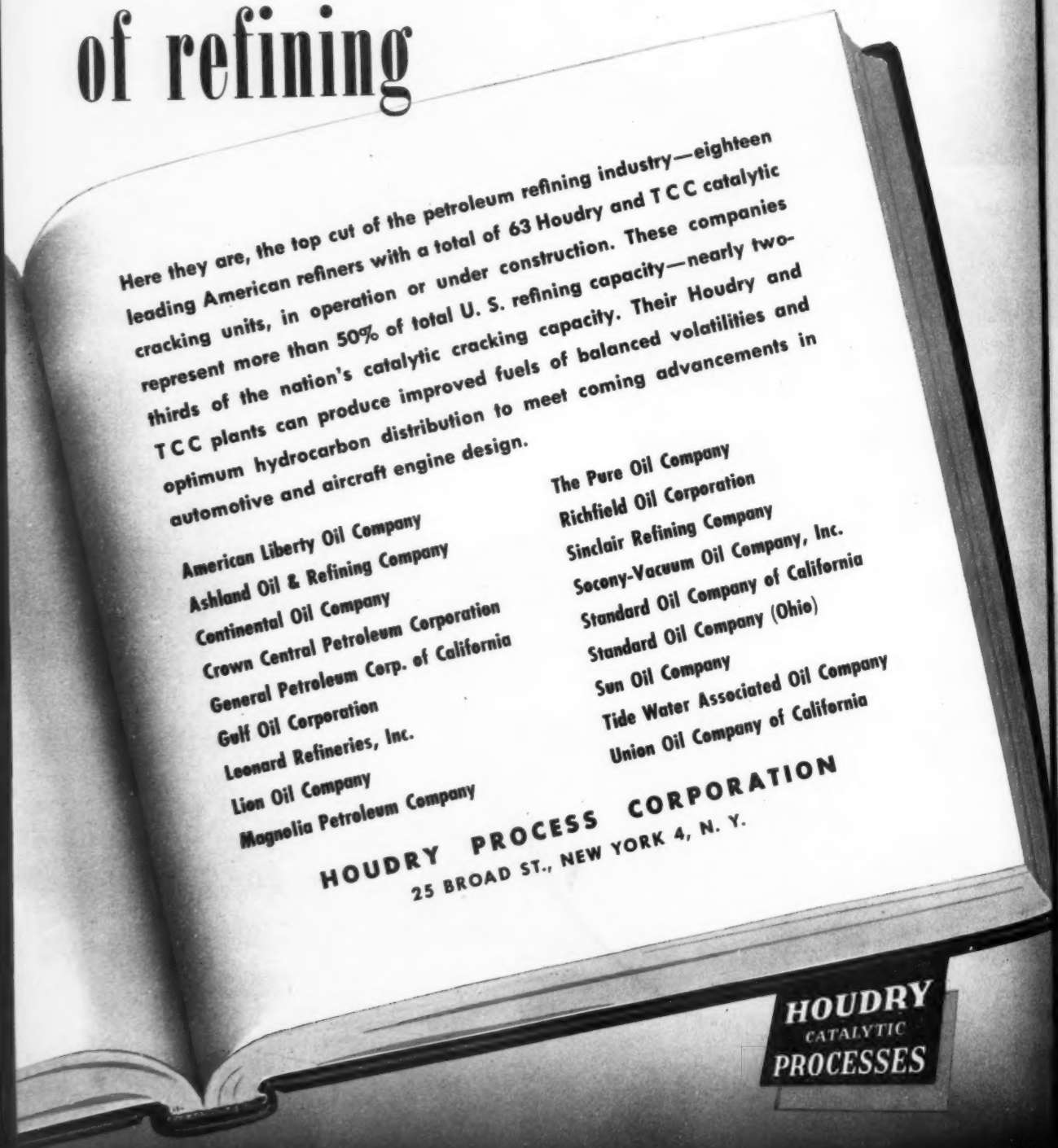
GAS ANALYSIS LABORATORY. Automatic low temperature fractionating columns assist in the gas analysis work.





PETROLEUM TESTING LABORATORY. One corner of the petroleum testing laboratory in which gasoline and other petroleum samples are subjected to all standard chemical and physical tests.

The list of Houdry licensees is the Blue Book of refining



Here they are, the top cut of the petroleum refining industry—eighteen leading American refiners with a total of 63 Houdry and TCC catalytic cracking units, in operation or under construction. These companies represent more than 50% of total U. S. refining capacity—nearly two-thirds of the nation's catalytic cracking capacity. Their Houdry and TCC plants can produce improved fuels of balanced volatilities and optimum hydrocarbon distribution to meet coming advancements in automotive and aircraft engine design.

American Liberty Oil Company
Ashland Oil & Refining Company
Continental Oil Company
Crown Central Petroleum Corporation
General Petroleum Corp. of California
Gulf Oil Corporation
Leonard Refineries, Inc.
Lion Oil Company
Magnolia Petroleum Company
The Pure Oil Company
Richfield Oil Corporation
Sinclair Refining Company
Socony-Vacuum Oil Company, Inc.
Standard Oil Company of California
Standard Oil Company (Ohio)
Sun Oil Company
Tide Water Associated Oil Company
Union Oil Company of California

HOUDRY PROCESS CORPORATION
25 BROAD ST., NEW YORK 4, N. Y.

HOUDRY CATALYTIC **PROCESSES**

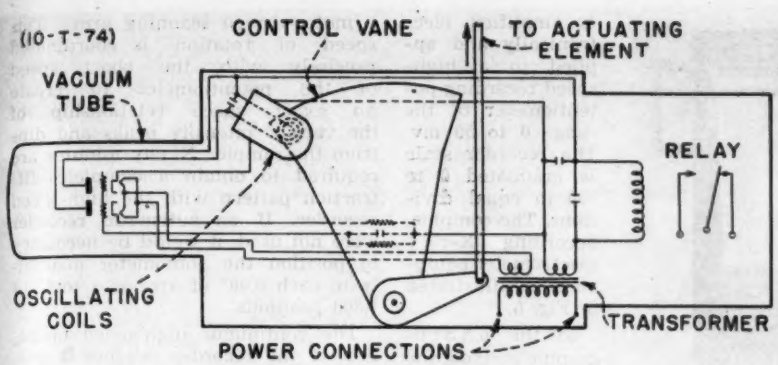


Fig. 4—(Courtesy Brown Instrument Co.)

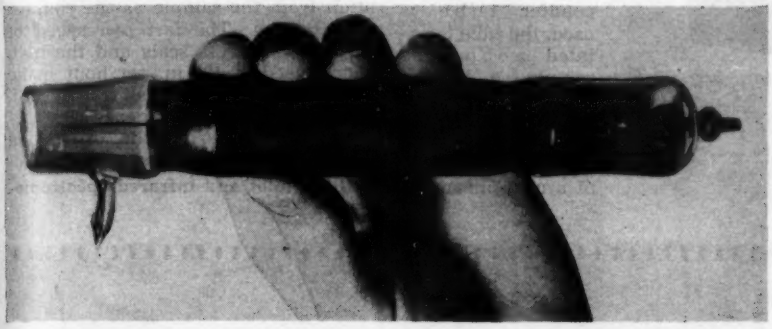


Fig. 5—Geiger Müller tube (Courtesy North American Philips Co., Inc.)

determines whether or not current will flow in the tube circuit.

The relative positions of various components of the control circuit within the new unit are shown in Fig. 4. A dual triode amplifier (7N7) vacuum tube is illustrated at the left of the diagram. The electronic circuit is such that one section of the tube is associated with the oscillating circuit as well as with the relay actuating coil, while the other section serves to supplement the actual oscillating tube current flowing through the relay coil. Use of the second section results in 60 per cent more current being available to operate the relay. If the first tube section should fail, sufficient current to hold the relay in cannot flow through the second section itself. Safe failure of the controller thus is assured.

A builtin transformer steps up line voltage to 250 volts and passes it to the vacuum tube, oscillator coils, and relay coil. The vacuum tube both rectifies and amplifies the direct current which actuates the relay coils.

Location of the vane, which is determined by the connection between the vane and the spiral in the thermometer or pressure gage, with respect to the two oscillator coils determines whether or not high frequency (oscillating) energy is permitted to pass between the coils. When the vane is not between the coils, this flow of high-frequency current suppresses the direct current to a point where it is insufficient to actuate the relay coil which is, therefore, deenergized. Upon moving between the coils, as shown in Fig. 4, the vane cuts off the induced high-frequency oscillation. The direct current, no longer suppressed, increases in strength practically instantaneously and energizes the relay coil and control action is effected.

By far the most important single feature of the new vane-type controller is the continuous or noncyclic control action which it provides. When the instrument pen or pointer deviates from the set point by as much as 0.1 per cent of full scale, immediate corrective action takes place through the snap action of the load relay. This simultaneous adjustment of the controlled variable in accordance with the demand of the process permits control of a quality formerly unobtainable with electrically operated thermometer or pressure controllers. Because of the small differential gap, this close control is accomplished without chattering of the relay contacts.

More and Better Detecting Means

Not all of the improvements brought to the field of instrumentation via electronics within the past few years have been confined to the rebalancing part of the instrument circuit as just described. Of importance today, but probably of much greater significance tomorrow, are the new and improved electronic means for detecting variables other than temperature. In the following paragraphs, several of the new detecting devices are described. It is believed that the trend represented by these measuring elements will result in a large change in process control techniques over the next several years, wherein direct, continuous measurements will replace many of the inferential methods in use today. Not all of the measuring elements described will become of primary importance to petroleum refiners, but because of the extremely rapid pace with which the industry moves, it is felt that specific predictions are unwise and that each item should be reviewed in view of the possible position which it may attain in the industry one day.

X-ray spectrometer. — With more and more attention being devoted to atomic and molecular structure and the production of extremely pure compounds for comparative and other purposes, the field of instruments useful in determining structure and analysis is becoming of increasing interest. One instrument which has come to the fore during the past few years is the Geiger-Counter X-ray Spectrometer.

Until comparatively recently, the time and technique required to perform and evaluate an analysis have limited the usefulness of this tool. The development of an X-ray spectrometer which greatly reduces the time required for analysis and which practically eliminates the need for special techniques in performing analyses is principally the result of two achievements in electronics, namely: (1) the Geiger-Müller tube, and (2) the continuously balanced high-speed electronic potentiometer recorder. Before the introducing of these electronic components, the X-ray patterns were obtained on photographic film. With the photographic method, considerable time was required to set up the unit and prepare the film before exposure, to expose the film (from 10 minutes to 10 hours), and to develop the film after exposure. Once the film was developed, there remained the time-consuming manual task of measuring the line spacings and evaluating the line densities. Careful measurements and computations had to be made to develop and to apply film shrinkage or extension factors, since the film dimensions were affected during development. Likewise, the density of the diffraction lines on the film, versus the actual intensities of the reflected beams causing the lines, is not a linear function, especially at the end zones. Integrity of results, therefore, could be expected only for the middle ranges except through the adoption of rather involved time-consuming end-range techniques. Obviously, numerous improvements were required of the photographic method.

The photographic film has been replaced by the Geiger-Müller tube illustrated in Fig. 5. The tube actual-

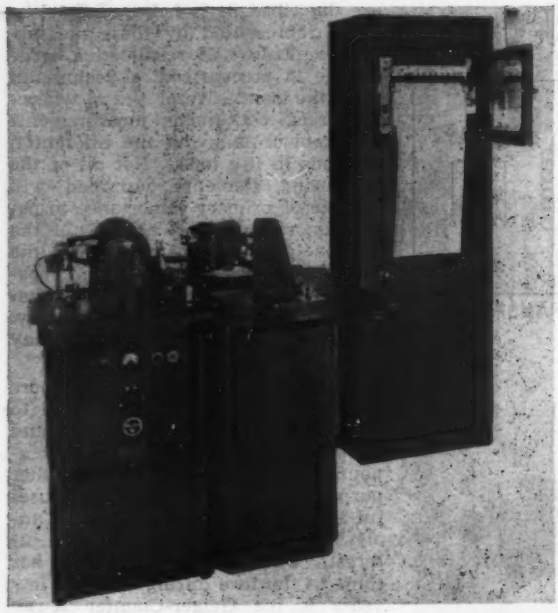


Fig. 6—(Above) Recording X-ray diffraction spectrometer (Courtesy North American Philips Co., Inc.)

ly counts the quanta of X-ray energy reflected from the sample. It is interesting to compare the sensitivity of the Geiger-Müller tube with that of the film. The tube produces one count for almost every X-ray quantum entering the tube; the film requires from 10^4 to 10^5 quanta to produce a diffraction line of minimum detectable darkness.

The Geiger-Müller tube essentially is a sealed tube containing an ionizable gas. Energy impinging on the tube causes partial ionization of the gas. The formation of a single ion pair anywhere within the active volume of the counter tube releases a flow of current sufficiently large to operate a relay directly. The voltage is amplified electronically and applied to a high-speed recording potentiometer of the range 0 to 50 mv. The recorder scale is graduated 0 to 100 in equal divisions. The complete recording X-ray spectrometer equipment is illustrated in Fig. 6.

In the photographic method, the strip of film is stationary. Where the counter tube is used, the tube is rotated about the sample so that it will scan the field of diffraction lines. The counter tube is rotated through 90° of arc by means of a motor-driven scanning arm. This speed of rotation is coordinated precisely with the chart speed of the potentiometer to create an exact space relationship of the various intensity peaks and dips from the sample. Ninety minutes are required to obtain a complete diffraction pattern with the high-speed recorder. If an automatic recorder were not used, it would be necessary to position the goniometer manually to each 0.05° of arc, or a total of 1,800 positions.

The continuous high-speed operation of the recorder renders it possible to detect almost instantaneously the changes in the secondary radiation from the sample as the counter tube rotates. The fast pen speed of 4.5 seconds across scale and the high chart speed of 120 in. per hour make it possible to spread out the record, contributing to convenience and accuracy in analyzing the diffraction pattern.

Ultraviolet and infrared spectrometers.—Few analytical tools gained so much in prestige during the recent war years as the ultraviolet and infrared spectrometers. Experience has proved the feasibility of applying these instruments to automatic control in continuous processing. True, there are many problems yet to be overcome before spectrometers can be applied to a process with the ease that a thermocouple pyrometer is applied, but large strides in the application of these instruments within the next 5 years are forecast.

Briefly, spectrometry is based upon the fact that chemical substances, in either the gas, liquid, or solid form, absorb light at certain wave lengths.

(Continued on page 260)

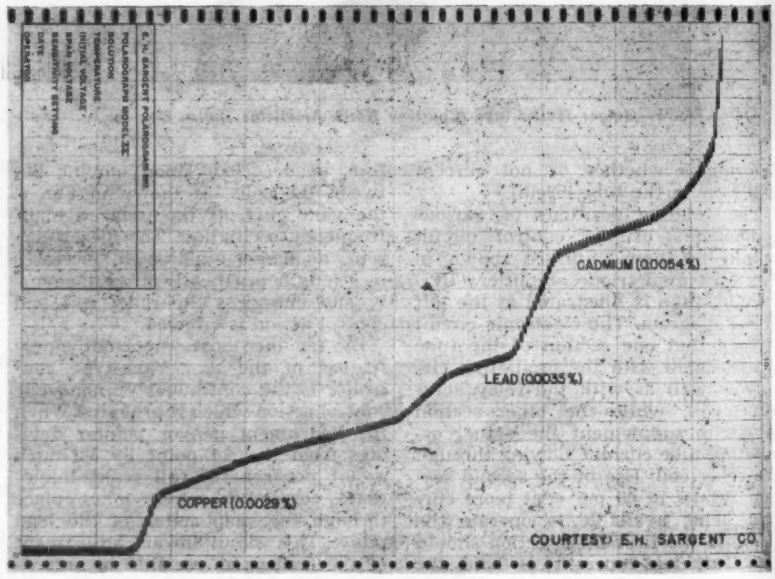


Fig. 8—Polarogram of copper, lead, and cadmium in a high-purity zinc-base die-cast alloy

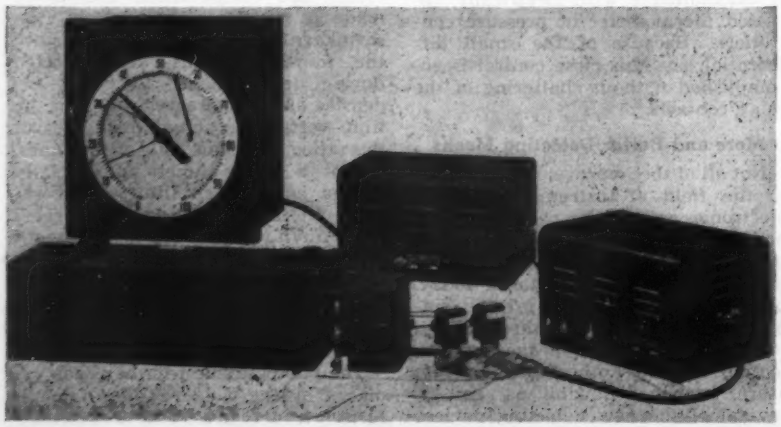


Fig. 7—(Below) Recording ultraviolet spectrophotometer (Courtesy National Technical Laboratories)

Briefly, spectrometry is based upon the fact that chemical substances, in either the gas, liquid, or solid form, absorb light at certain wave lengths.

(Continued on page 260)

LEFT ABOVE—Pipe Line Transmission

RIGHT ABOVE—Vapor Re-Compressing and Refrigeration Service

AT RIGHT—Electrical Power Generation

THE photos on these pages give only an inkling of the 15,830 Cooper-Bessemer horsepower serving the El Paso Natural Gas Company at Jal, New Mexico. Most of the units are modern, long-lived GMV-angle compressors, with six, eight, and ten cylinder V-type engines, for pipe line transmission of field gas, for refrigeration service in gasoline extraction, and for transmission of residue gas into the main line system. Still other Cooper-Bessemers provide for repressuring, vapor re-compressing, and electrical power generation.

Most recent addition, shown in the photos opposite, consists of a 1000 hp GMV-10 and eight 6-cylinder, 600 hp GMV's . . . all for compressing residue gas. The GMV-10, driving four compressor cylinders, alone handles approximately 7,000,000 cubic feet of gas a day.

In El Paso Natural Gas Company operations as a whole, Cooper-Bessemer to date has supplied 44,680 out of a total 52,980 compressor horsepower. Now, 25 more GMV's for field and main line service are on the way . . . an additional 23,800 horsepower!

Companies who use GMV's who have had experience with these fine, modern units, re-order again and again as new needs arise. Don't you think that's just about the best kind of evidence of outstanding performance?

by **Cooper-Bessemer**

MOUNT VERNON, OHIO AND GROVE CITY, PENNA.

Houston, Dallas, Greggton, Pampa and Odessa, Texas Tulsa Shreveport St. Louis Los Angeles

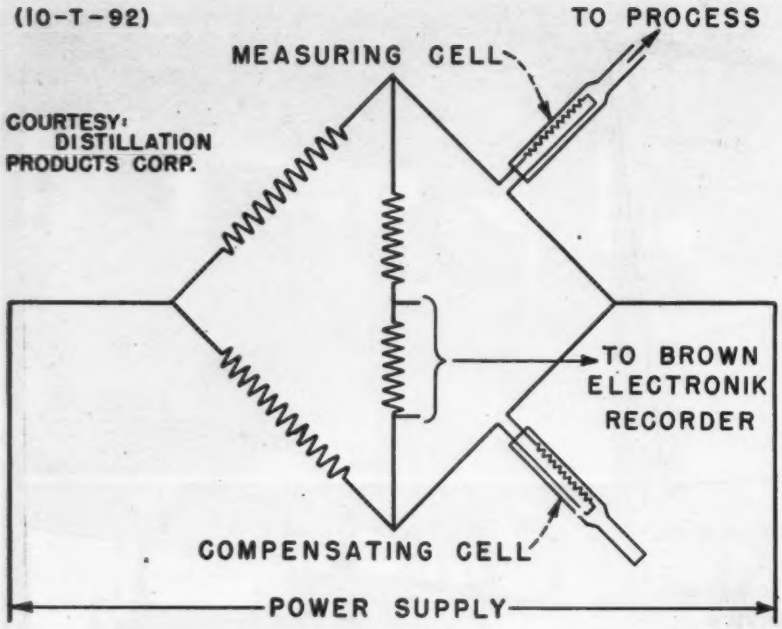


Fig. 9

When light of a single color or wave length is passed through a layer of any substance, the light may be transmitted completely, or it may be partially or completely absorbed by the substance, depending upon the chemical identity of the substance and the amount of the substance in the path of the light. If a plot is made of wave length versus percentage of light absorbed under various conditions, an irregular curve of hills and valleys will result. The hills correspond to wave lengths or colors for which the substance is relatively opaque; the valleys correspond to wave lengths for which the substance is relatively transparent. Fortunately, the absorption curve for any substance is unique. The absorption spectrum serves as a fingerprint to identify the substance when in pure form.

When the substance is mixed with others, usually it will be found that at least some of the absorption peaks of the substance do not coincide with the absorption peaks of the other substances, rendering identification possible.

Molecules which include the benzene ring in their structure, such as benzene, toluene, and xylene show distinctive absorption patterns in the ultraviolet region. Ordinary saturated hydrocarbons, such as propane and butane, on the other hand, show patterns in the infrared region.

The average ultraviolet spectrometer comprises (1) a source of ultraviolet radiation, usually a hydrogen lamp, (2) a monochromotor to isolate radiation of any desired wave lengths, (3) an absorption cell through which a stream of the fluid being measured is continuously passed, (4) a phototube and electronic amplifier for measuring the amount of radiation transmitted through the sample, and (5) an electronic potentiometer which records the percentage of light transmitted by the sample. By employing suitable calibration data, the per cent transmission can be correlated with the concentration of the measured substance in the fluid stream. A recording ultraviolet spectrometer is illustrated in Fig. 7.

In the infrared spectrometer, a globar usually is used as the source of infrared radiation. This radiation is focused through a sample cell. Radiation transmitted by the sample cell is dispersed by means of a prism. By rotating a Littrow mirror, upon which radiation from the dispersing prism strikes, it is possible to select the radiation of desired wave length which will be focused upon the measuring thermocouple. The thermocouple may be of the high-vacuum compensated type. The amount of energy for a given wave length picked up by the thermocouple is a function of the amount of radiation of that wave length absorbed by the sample. The thermocouple e.m.f. is amplified and recorded on a high-speed strip chart electronic potentiometer.

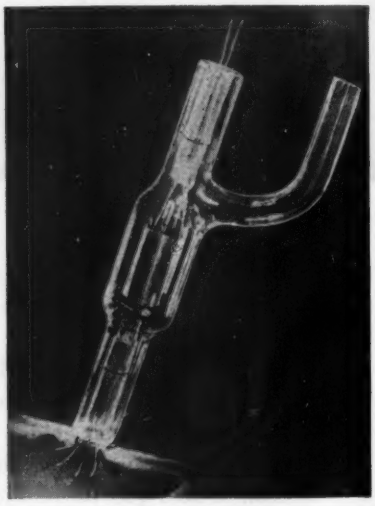


Fig. 11

Advantages of continuously and automatically indicating and recording ultraviolet and infrared spectra include: (1) the time and skill required to perform analyses are minimized, (2) a permanent record is obtained which may be consulted for reference at any time, and (3) unknown absorption in samples often can be identified at a later date in view of subsequent work providing a permanent record is at hand.

Recording polarograph.—Control of trace materials by standard chemical methods is frequently difficult and tedious. Determination of traces may

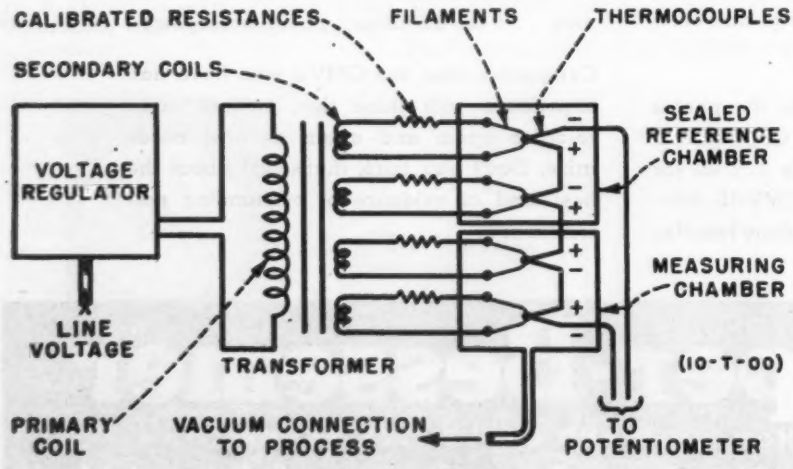


Fig. 10—(Courtesy Geo. E. Fredericks Co.)

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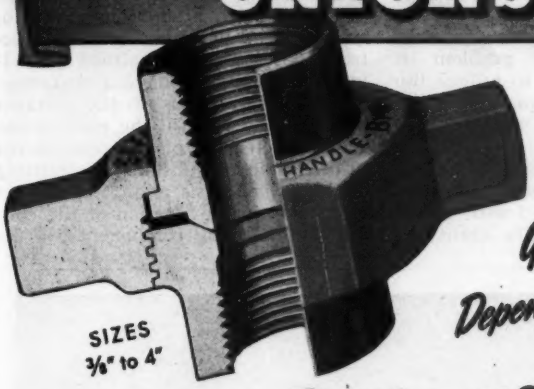

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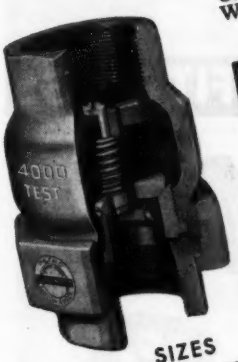

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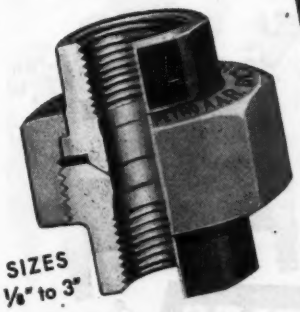

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take hours or days. In many cases, a batch may be held up for long periods awaiting a laboratory report. Frequently, procedure forces the batch through with subsequent rejection on the basis of its final analysis. This procedure leads to wasteful reprocessing or the sale of a substandard product. The problem of the control engineer is to reduce the time lag so that the quality of the product is known in time to make the needed corrections.

The recording polarograph is well suited to many phases of process control because of the speed with which analyses are obtained. The ability of the polarograph to analyze for organic constituents makes the instrument especially useful in the chemical end of the petroleum business.

This instrument is based upon the fact that the current-voltage curves produced when a solution is electrolyzed with a dropping mercury electrode have certain qualities, including: (1) the curves have a characteristic step formation, (2) the voltages at which the steps of the curve occur are characteristic of the components in the reducible substance, permitting qualitative analysis, and (3) the height of the steps is a function of the concentration of the components of the substance in solution, thereby making quantitative analysis possible.

The dropping mercury electrode comprises a fine-bore capillary tube connected by a rubber tube to a mercury reservoir and placed in the solution so that very fine drops of mercury are formed beneath the surface. The rate of mercury flow may be adjusted by varying the height of the mercury reservoir and normally amounts to a drop every 1 to 3 seconds. The mercury reservoir is connected to one terminal of the polarograph; the other cell terminal is a pool of mercury in the bottom of the solution vessel.

In operation, a few drops of mercury added to the sample, act as one electrode of the cell. The dropping mercury electrode is next inserted. An inert gas, usually nitrogen, is then bubbled through the solution to remove atmospheric oxygen which is reducible and gives a polarographic wave not usually of interest to the analyst. As the voltage impressed on the cell is slowly raised, the current remains nearly constant until a voltage is reached at which a component of the solution is reducible. The current then rises sharply to a new level, at which it remains constant until the voltage is reached at which a second component is reducible. Another sharp rise in current to a new constant value then occurs. These sharp rises in current are called polarographic steps or waves. A typical polarogram is illustrated in Fig. 8.

Improvements in pH measurement. —Closely allied with the measurement of chemical composition is pH measurement. Because the greatest volume of liquids handled in the petroleum industry are essentially nonaqueous, the importance of pH measurement to refining undoubtedly will be limited. Numerous interesting uses have been found for pH measurement over the past few years, however, including the protection from corrosion of costly condensers and allied equipment. For those petroleum engineers who may not have reviewed the field of pH instruments recently, the following factors should be considered: (1) pH no longer is limited to low temperatures, but can be measured in boiling aqueous solutions, (2) accurate pH measurement in alkaline solutions, containing sodium ion concentrations of 2 moles per liter and up to a pH of 12 is now obtainable, (3) unreasonably delicate handling of electrodes is no longer required, and (4) the effects of stray currents upon electronic pH equipment have been eliminated through shielding. pH measuring and controlling systems are available today, of course, with complete compensation for temperature changes in the solution being measured. Two principal electrode constructions are available, namely, the flow-type assembly, designed for installation directly in process pipe

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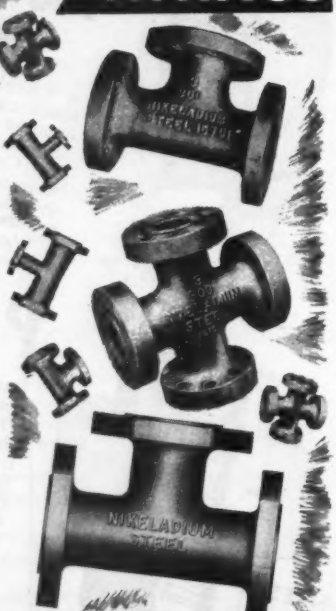

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lines, and the immersion type assembly, designed for installation in tanks, vats, or other processing vessels. Numerous materials of construction, including porcelain covered iron, rubber, stainless steel, Monel metal, and Pyrex glass are used for fabrication of the electrode assemblies.

Measurement of high vacuums.—Whether the application of high vacuums to petroleum processing will increase as rapidly as it has in other industries, such as food and pharmaceutical processing, is difficult to predict. Suffice it to state at this point that accurate, practical vacuum measuring, recording, and controlling equipment is now available and should be known to the petroleum engineer—at least in its basic aspects.

Not too long ago, an absolute pressure of a few millimeters of mercury was considered a fairly high vacuum. With exception of the manufacture of vacuum tubes, high-vacuum techniques generally were confined to the laboratory. Today, absolute pressures in the low millimeter and micron ranges are becoming commonplace and making practical many processes formerly impossible to carry out and are improving the performance of many products.

The Pirani gage operates by virtue of the ability of a residual gas in an evacuated system to conduct heat away from a hot filament. At pressures between that of the atmosphere and 1,000 μ of mercury pressure absolute, there is very little change in the filament heat loss with changes in pressure. Below 1,000 μ and especially below 500 μ, the changes in heat loss with changes in pressure are relatively large. The relationship between filament heat loss and absolute pressure is definite and serves as a reliable and accurate basis for pressure measurement. As the vacuum surrounding the filament becomes greater, the filament grows hotter. On the other hand, as the vacuum falls off, the filament grows cooler.

The Pirani gage is illustrated schematically in Fig. 9. It consists essentially of a coil of resistance wire mounted in an envelope which is connected to the system whose pressure is to be measured. The gage is connected into a Wheatstone bridge as one of the four arms. A second gage is usually sealed off at a pressure considerably lower than 1 μ of mercury and is connected to the bridge as a second arm and is so arranged that changes in its resistance will balance changes in the gage tube resistance due to temperature fluctuations, but not due to pressure changes. The remaining two arms of the bridge are equal fixed resistances.

As illustrated in Fig. 10, the Televac thermal gage also operates on the ability of the residual gas to conduct heat away from a hot filament. The filament is heated continuously and

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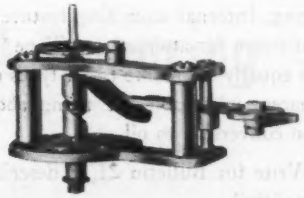

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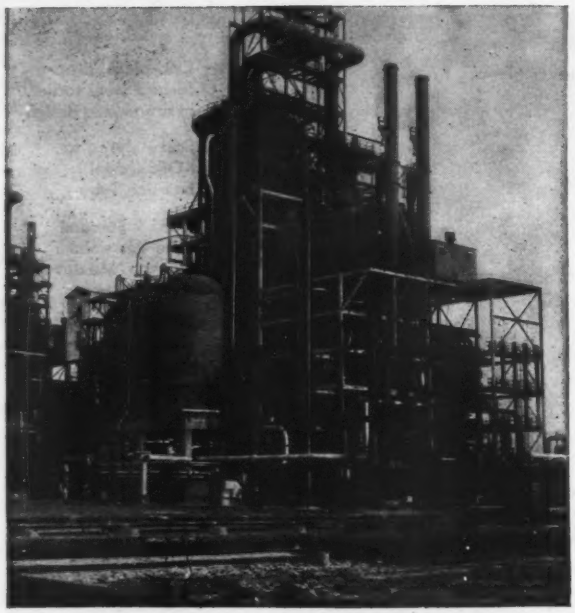

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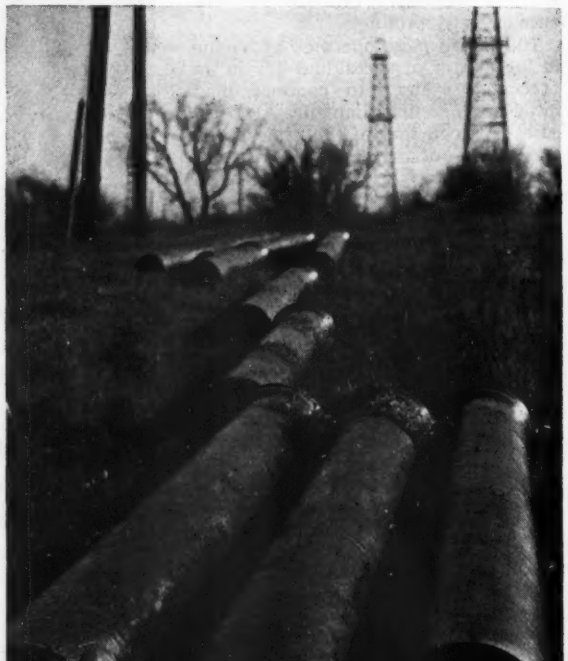

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uniformly by an electric current of constant voltage. Line current is passed through a voltage regulator and then to the primary coil of a transformer. Four secondary coils of the transformer each supply current to four separate filaments. The current to each filament is held constant by means of carefully adjusted resistance coils in series with the transformer secondary coils.

There are two filaments in the measuring chamber of the gage and two filaments in a sealed reference chamber. The reference chamber is sealed at a pressure of 1 μ of mercury at the factory and remains unaltered during the life of the gage. A small, sensitive thermocouple is incorporated on each filament to measure the filament temperature. Note that the two thermocouples in each chamber are connected in series to provide a greater e.m.f. Also note that the four thermocouples in the measuring circuit are electrically connected so that the e.m.f. from one set of couples, in a reference chamber, tends to cancel the e.m.f. from the other set of couples, in the measuring chamber, leaving only the residual e.m.f. to be detected—which, of course, is a measure of the difference in pressure between the sealed reference chamber and the measuring chamber.

The e.m.f. from the gage, which varies from 0 mv. at 1 μ of pressure up to approximately 19.2 mv. at a pressure of 500 μ of mercury, is measured and recorded by an electronic potentiometer.

The ability of electrons emitted from a hot filament to bombard the molecules of residual gas in an evacuated system is the basic principle of the Televac ionization gage illustrated in Fig. 11. The flow of ions formed through ionization of the residual gas is a direct measure of the amount of gas present and hence of the absolute pressure or vacuum.

Essentially, the gage is a triode tube, comprising filament, grid, and plate. Electrons emitted from the filament are accelerated to the grid and would be carried on to the plate were there not an electrical field impressed between the grid and plate to prevent this. Therefore, the electrons return to the grid and are collected on it. It is in this passage between the grid and the plate that the electrons bombard the gas molecules, thus forming ions.

Measuring systems—ad infinitum.—Space limitations have confined the discussion of the newer electronic measuring elements to a small percentage of those now available. Instruments were introduced recently for determining the dew point of gases, the specific gravity of liquids, the absolute humidity of air, etc. Many of these instruments are not yet perfect, but certainly much more will be heard of them within the next few years.

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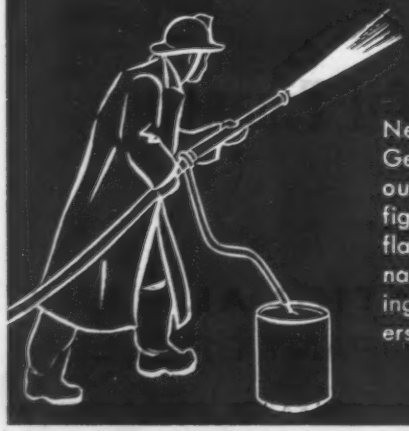

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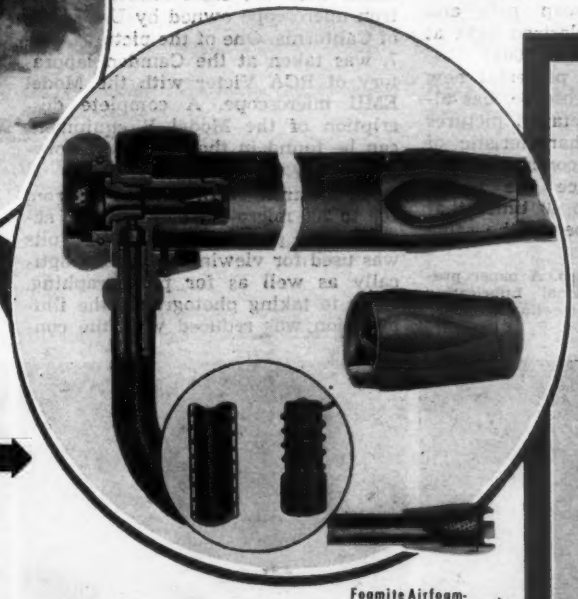
The Foamite Airfoam-Generating Nozzle is furnished in two capacities, Models 300 and 600 producing at 100 psi operating pressure, approximately 300 and 600 gallons of Foamite Airfoam respectively.

*Patents pending on this new Foamite Airfoam-Generating Nozzle.



Shown is sectional view of Model 600 Foamite Airfoam-Generating Nozzle. It mechanically creates Foamite Airfoam thru a scientific mixing of water, air, and Foamite Airfoam Liquid. Phantom view shows specially designed "tear drop" obstruction for giving stream equal velocity on leaving tip. Note wire-reinforced pick-up hose construction.

Foamite Airfoam-Generating Nozzles, Models 600 and 300.

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Study of Lubricating Greases by ELECTRON MICROSCOPE

by B. B. Farrington and D. H. Birdsall**

IN 1936 one of the writers[1] presented the results of a study of the structure of lubricating greases by means of the microscope with dark field illumination. In that investigation the resolving power of the best available microscopes was only sufficient to discover the fine structure of the soap fibers in sodium soap greases. The magnification was found inadequate to resolve the detailed structure of the soap particles in calcium and aluminum soap greases. Since calcium soap greases form the bulk of grease products marketed, a considerable field of research was blocked by the limitation of the tools then available. The evidence indicated, however, that all greases owe their peculiar plastic properties to the fiber structure of the soap particles which permeate and support the mineral oil component.

Later Lawrence[2] and Gallay, Puddington, and Tapp[3] published micrographs of sodium soap gels and greases taken with polarized light at low magnifications (74 to 200x).

The invention of a powerful new tool, the electron microscope, has allowed us to obtain detailed pictures of the soap fibers characteristic of most of the types of commercial lubricating grease, since the useful magnification is up to 40 times that of the light microscope on the same material.

*California Research Corp. A paper presented before the National Lubricating Grease Institute annual meeting, October 1946.

THE electron microscope permits the chemist to discover facts about soap fibers unknown heretofore; this microscope magnifies up to 40 times as high as the conventional light microscope. Accelerating potentials of 55,000 volts with an electron beam current of 100 to 200 micro-amperes was used in this study. Collodion films were used to support specimens of greases. This technique permits seeing soap fibers never before visible, but does not give data as to physical or chemical properties which may be discovered probably by studying greases or soaps before and after laboratory or service tests have been carried out. Soap fibers studied varied in length from 0.0002 to 0.05 mm.

The micrographs which are here presented were, with one exception, taken with the RCA Model B electron microscope owned by University of California. One of the pictures, Fig. 7, was taken at the Camden laboratory of RCA Victor with the Model EMU microscope. A complete description of the Model B equipment can be found in the book by Zworykin et al.[4]

An electron beam current of from 100 to 200 micro-amperes with an accelerating potential of 55,000 volts was used for viewing specimens optically as well as for photographing. Prior to taking photographs the illumination was reduced with the condenser control until exposures of from 5 to 8 seconds gave satisfactory results on lantern slide medium plates.

Preparation of Grease Samples

The preparation of the grease samples for observation required considerable study, chiefly because only extremely thin films of grease are transparent enough to examine with the electron microscope. Attempts were made to obtain satisfactory specimens by several methods, including diluting the grease with volatile solvents, kerosene, and medicinal white oils (for heavy greases). The most reliable method found consists of simply smearing the grease out on a glass slide into a thin film and then transferring a minute amount to a previously prepared collodion film by means of a tiny glass rod. The collodion film (transparent to electrons) was made by the standard electron microscope technique; i.e., a collodion solution was deposited on water, the small supporting screen dropped on to the collodion film, the two picked up on a glass slide, allowed to dry, and the tiny wire screen with the adhering collodion film cut or torn from the bulk of the deposited film.

In many cases it was found advantageous to wash the oil from the prepared grease specimen by allowing a drop or two of petroleum ether to fall upon the collodion-supported grease smear held at an angle. The

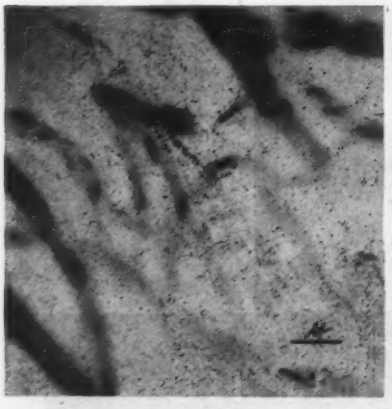


Fig. 1—Sodium soap grease (No. 1) medium fiber (8,000 x)

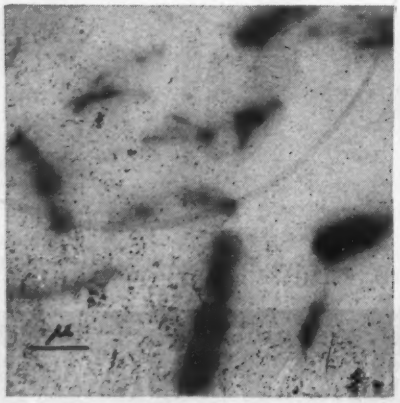


Fig. 2—Sodium soap grease (No. 2) short fiber (9,000 x)

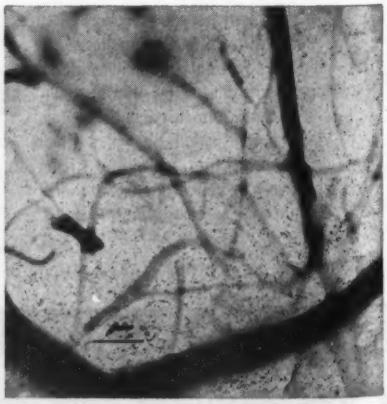


Fig. 3—Sodium soap brick grease (No. 3) thinned with white oil, petroleum ether washed (8,000 x)

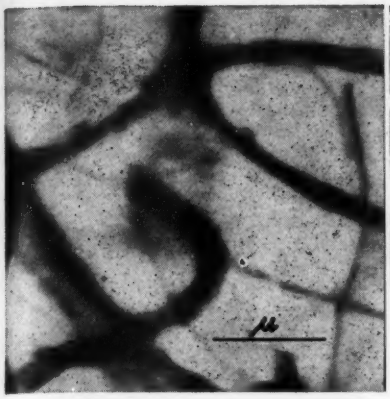


Fig. 4—Sodium soap brick grease (No. 3) thinned with white oil, petroleum ether washed (16,400 x)

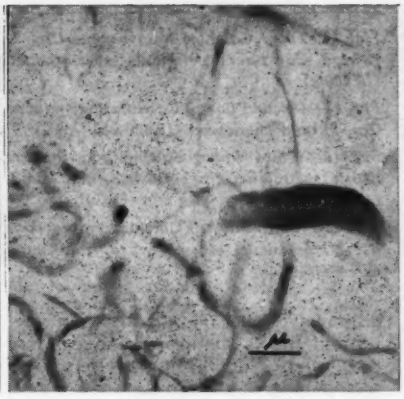


Fig. 5—Sodium soap brick grease (No. 4) thinned with white oil, petroleum ether washed (8,000 x)

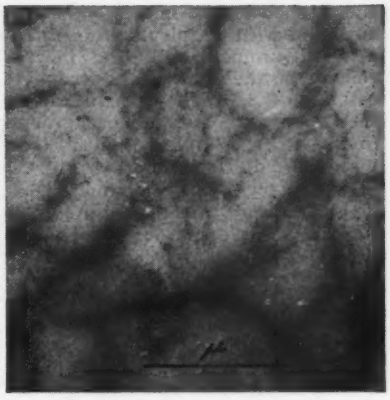


Fig. 6—Calcium soap grease (No. 5) wavy soap fibers (21,000 x)

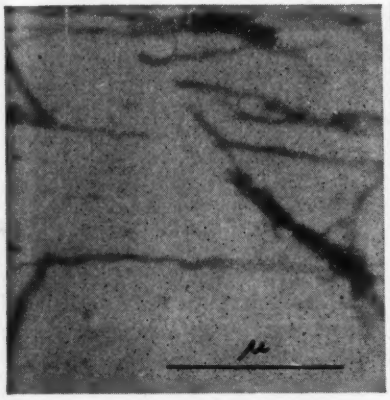


Fig. 7—Calcium soap grease (No. 6) stretched soap fibers (26,000 x)

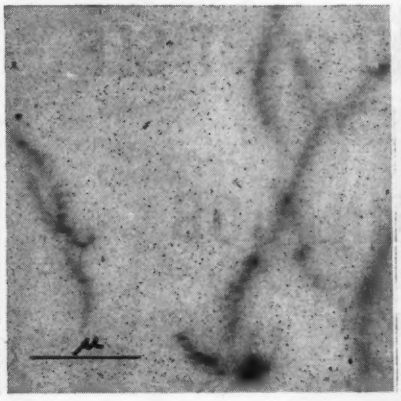


Fig. 8—Calcium soap grease (No. 6) twisted soap fibers (16,400 x)

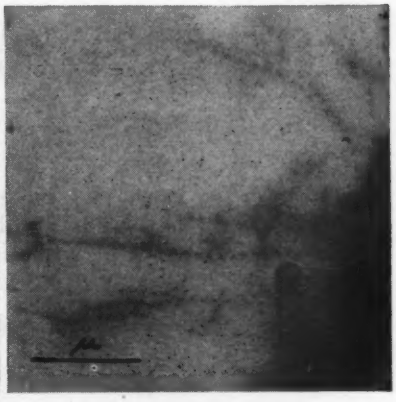


Fig. 9—Calcium soap grease (No. 7) twisted soap fibers (16,400 x)

soap fibers were thus freed from obscuring oil. Micrographs were always taken of the unwashed grease for comparison to determine if swelling or distortion of the soap fibers occurred.

Grease Micrographs

The following micrographs illustrate the various types of soap fiber encountered in commercial types of lubricating grease. Original magnifications were 4,000x and 8,000x with the exception of Fig. 7 which was taken at 13,000x. Enlargements in the final prints from these magnifications are photographic. The soap fibers shown are, of course, not pure chemical compounds but metal salts of the mixed fatty acids of commerce. The pertinent data characterizing the various greases shown are given in Table 1.

Fig. 1 shows a medium-fiber sodium soap grease in which the ribbon-like character of the sodium soap fibers is clearly demonstrated, the twist in the large fiber in the upper right corner being noteworthy.

In Fig. 2 the grease shown in the previous picture has been milled with a small amount of additional oil. It will be seen that the ribbon-like soap fibers have been chopped up with little axial splitting.

Figs. 3, 4, and 5 show sodium soap brick greases, mixed with white oil to thin out the fiber concentration.

TABLE 1

Grease No.	A.S.T.M. Worked Pen.	Soap		Oil				Approx. Fiber Dimensions (μ)*		
		Type	%	%	Vis./ 100 S.S.U.	Vis./ 210 S.S.U.	V.I.	Length	Width	Thickness
1	260	Sodium	25	75	482	60.9	85	40-50	0.2-0.5	0.06
2	310	Sodium	20	80	482	60.9	85	1.2-3.4	0.1-0.4	0.06
3	38 (Unworked)	Sodium	27	73	2,700	104	10	Heterogeneous		
4	55 (Unworked)	Sodium	33	67	150	43.2	101	Heterogeneous		...
5	320	Calcium	11	89	200	42.8	5	0.5-1.0	0.01-0.04	...
6	285	Calcium	12	88	200	42.8	5	1.0-1.5	0.05	0.015 (Stretched)
7	365	Calcium	6	94	1,890	90	15	0.8-1.8	0.04	..
8	330	Barium	14	86	507	55.1	36	1.3-3.0	0.01-0.04	...
9	285	Strontium	32	68	1,910	127	96	15+ Large	0.07-0.12	0.02
10	320	Strontium	21	79	118	39.4	32	1.8-2.4 Small 0.2-0.5	0.12-0.16 0.01	...
11	315	Lithium	15	85	58.9	34.2	50	0.6-1.2	0.01	..
12	150	Lithium	20	80	463	51.6	10	0.2-0.6	0.03	...
13	340	Aluminum	12	88	391	56.7	92	....	....	....

*1μ = 0.001 mm.

and washed on the microscope specimen film with petroleum ether to remove all mineral oil. The heterogeneity of the soap fibers is apparent. Fig. 4, at higher magnification, shows a wealth of small background fibers. In Fig. 5 the soap fibers tend to be curved or sinuous.

Figs. 6 to 13 are electron micrographs of conventional hydrated calcium soap greases for which the grease specimens were prepared by various techniques. Fig. 6 shows the wavy appearance of the calcium soap fibers as they exist in the grease. It was at first thought that this effect might have been produced by dehydration in the electron microscope but specimens which were left in the microscope for periods up to 1 hour exhibited no structural change from those photographed immediately after introducing them into the instrument.

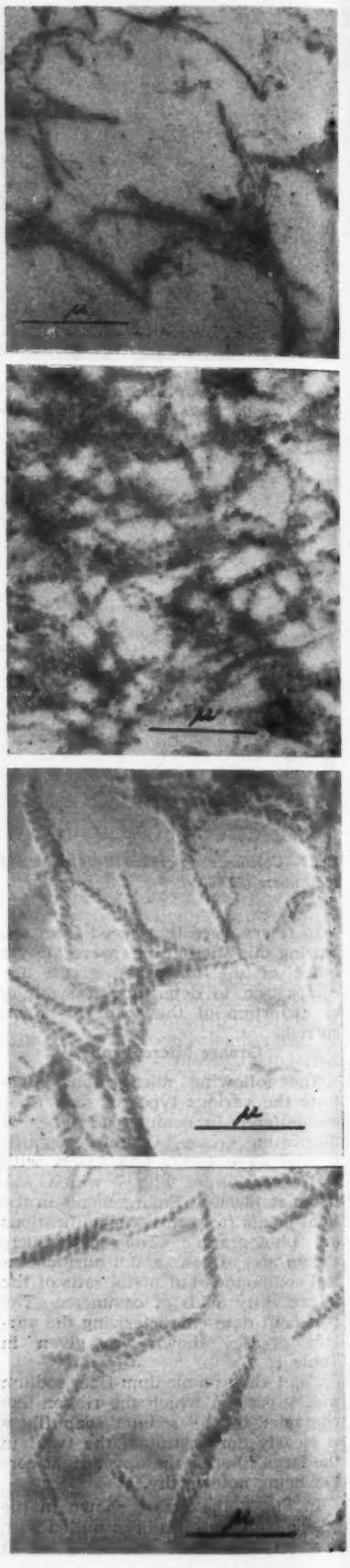
(Continued on page 275)

Fig. 10—(Top) Calcium soap grease (No. 7) twisted soap fibers, petroleum ether washed (16,400 x)

Fig. 11—(Second down) Calcium soap grease (No. 5) gold shadowed (16,400 x)

Fig. 12—(Third down) Calcium soap grease (No. 5) petroleum ether washed, gold shadowed (16,400 x)

Fig. 13—(Fourth down) Calcium soap grease (No. 5) petroleum ether washed, gold shadowed (16,400 x)



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In Fig. 7, taken at higher magnification, the calcium soap fibers appear to be stretched and more ribbonlike. Fig. 8, however, is more typical of the calcium soap fibers, the barber-pole appearance of the rather stiff-looking fibers being evident.

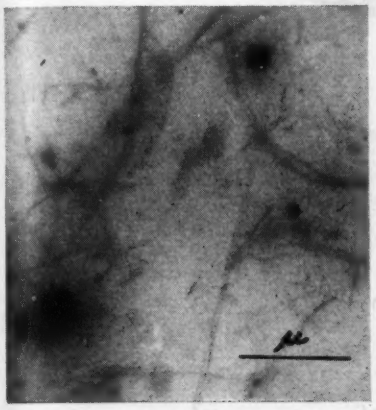
Figs. 9 and 10 show the same calcium soap grease; in Fig. 10, however, the grease was washed with petroleum ether to free the calcium soap fibers of oil. It is seen that much clearer pictures are obtained in this case with no visible distortion of the soap fibers.

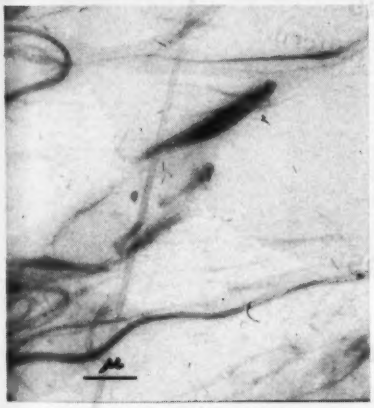
In Figs. 11 to 13, the calcium soap fibers were gold shadowed as described by Williams and Wyckoff.[5] The greases were mounted on specimen screens in the manner described previously. The prepared specimens were then placed in a bell jar which was evacuated prior to shadowing. The evaporation source consisted of a V-shaped filament of 20-mil tungsten wire. A piece of gold wire was hung from the V and fused to the tungsten by heating electrically in a vacuum.

The specimens to be shadowed were placed at a distance of about 2 cm. from the filament and in such a position that the angle from the specimens to the filament was about 10°. It was found that contrast and detail were improved at sharp shadowing angles. A vacuum of at least 3 microns was necessary for sharp shadows at 2 cm. from the filament.

The actual shadowing operation was of approximately 15 seconds duration at a filament current of 8 to 10 amp. Properly shadowed specimens had a slight gold tinge which could be observed through the bell jar.

All satisfactory gold-shadowed pictures were of greases from which the base oil had been removed with petroleum ether prior to shadowing. It





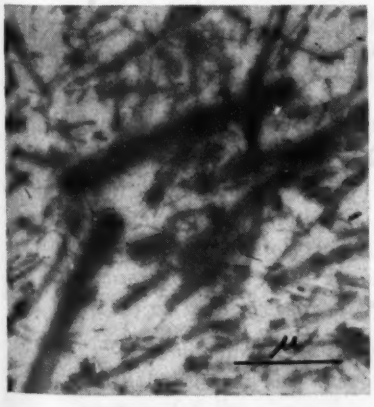


Fig. 14—(Top) Barium soap grease (No. 8) (18,400 x)

Fig. 15—(Center) Strontium soap grease (No. 9) filamentous fibers (8,000 x)

Fig. 16—(Bottom) Strontium soap grease (No. 10) rod-like fibers (18,400 x)

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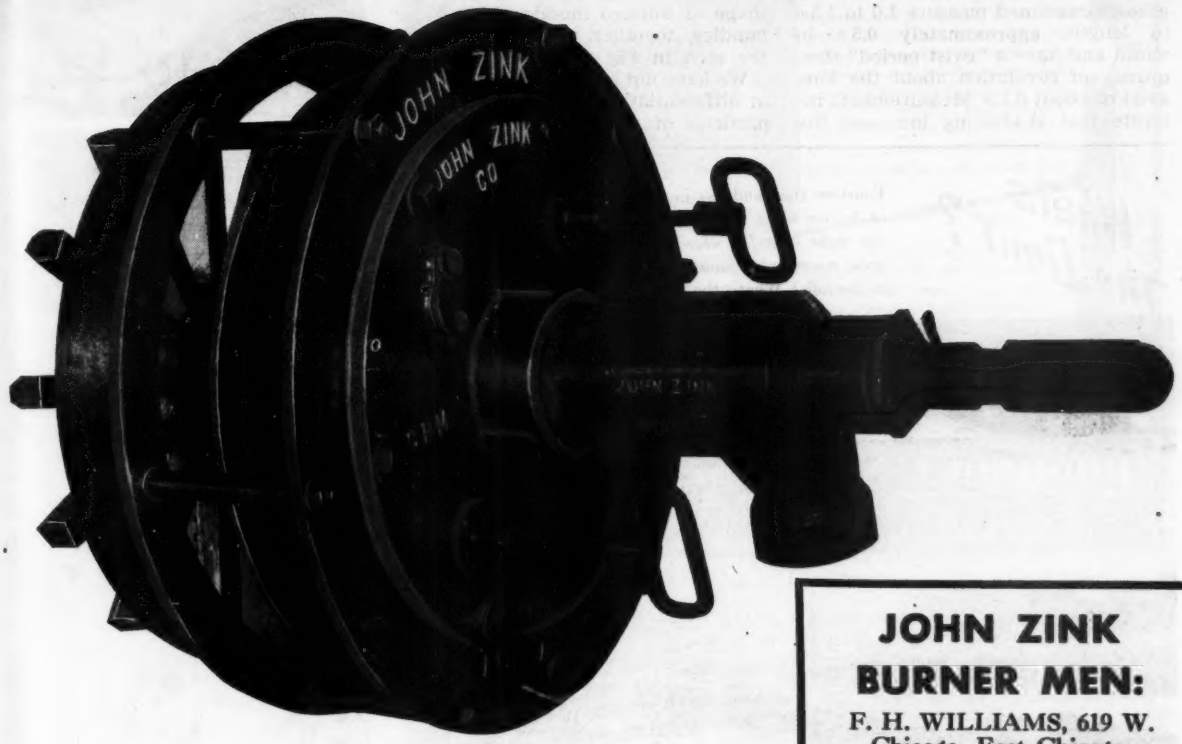

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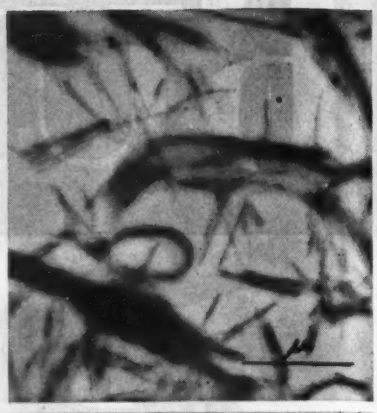
was found that little was gained from shadowing if the oil phase was left in the grease. This is shown by a comparison of Fig. 11 with Figs. 12 and 13. The twisted rope-like calcium soap fibers show many interesting forms. A study of Figs. 12 and 13 will show fibers having right-hand and left-hand twists, fibers which have apparently grown through one another (see lower right corner of Fig. 13) and a few wavy fibers that have unraveled. Calcium soap fibers of the greases examined measure 1.0 to 1.5 μ in length, approximately 0.5 μ in width and have a "twist period" (frequency of revolution about the long axis) of about 0.1 μ. Measurements indicate that shadowing increases the fiber dimensions somewhat, possibly due to gold deposition.

Barium soap fibers are shown in Fig. 14 and two types of strontium soap fibers in Figs. 15 and 16. Whether the filamentous forms of Fig. 15 or the rod-like fibers of Fig. 16 are obtained depends upon variables such as mineral-oil type and manufacturing procedure.

The lithium soap fibers shown in Figs. 17 and 18 are needle-like, those in Fig. 18 being about the size and shape of tobacco mosaic virus. Fiber bundles, together with single fibers are seen in Fig. 17.

We have not been successful to date in differentiating the individual soap particles of aluminum soap greases.



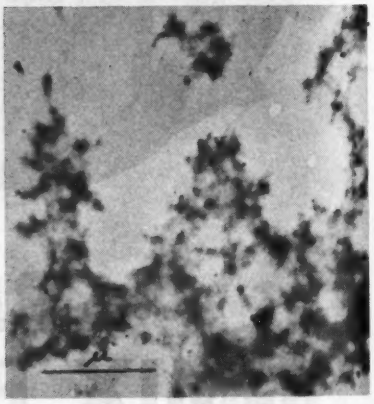


Fig. 17—(Top) Lithium soap grease (No. 11) fiber bundles (16,400 x)

Fig. 18—(Center) Lithium soap grease (No. 12) needle-like fibers (16,400 x)

Fig. 19—(Bottom) Aluminum soap grease (No. 13) (16,400 x)

Typical aluminum soap clumps are shown in Fig. 19. Although at first it was thought that the soap particles consisted of very small fibers, experimental work (in progress) has cast doubt on this view. Further research with the gold-shadowing technique will be required to settle this point.

Discussion

Although the electron microscope allows us to see before our eyes the soap fibers making up the backbone

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of most types of lubricating greases, it gives us no direct measure of their physical properties such as melting point and mechanical strength. The stability of these fibers can perhaps best be studied by electron microscope examination of the greases before and after laboratory or service tests. The effect on the fibers of variation in methods of manufacture, raw materials and additives can no doubt be studied with benefit by means of the electron microscope. Correlation of these findings with physical properties of the grease and service performance is the ultimate goal of studies of this kind.

Conclusions

1. The higher magnification made possible by the electron microscope has shown that in all soap-type lubricating greases so far examined (with the possible exception of aluminum base greases) the soap particles are fibrous in nature. This applies especially to some lithium and strontium soap grease particles which are invisible to the ordinary light microscope.

2. The soap fibers of the greases examined varied in length from less than 0.2 μ (0.0002 mm.) to 50 μ (0.05 mm.), the length to width ratio being from 10:1 to over 200:1.

3. Soap fibers of conventional hydrated lime soap greases are twisted; all other fibers studied were in the form of rods or ribbons.

Acknowledgment

Grateful acknowledgment is made by the authors to W. E. Rettig, who took some of the micrographs shown, and to University of California, physics department and the RCA Victor Division of Radio Corp. of America for the use of their equipment.

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German Plant Described

German plans for an experimental distillation plant to extract ethylene and methane from benzol but destroyed by bombing before operations began, are described in a report available from the Office of Technical Services, Department of Commerce, in Washington. Also included in the report is a description of a high-pressure German benzol system which purified 1,700,000 cu. m. of gas daily at a coke plant.

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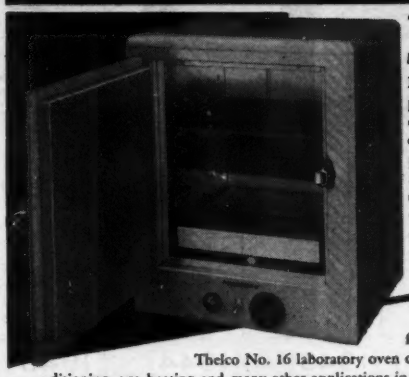

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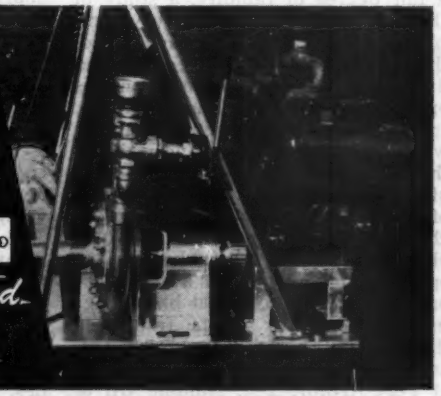

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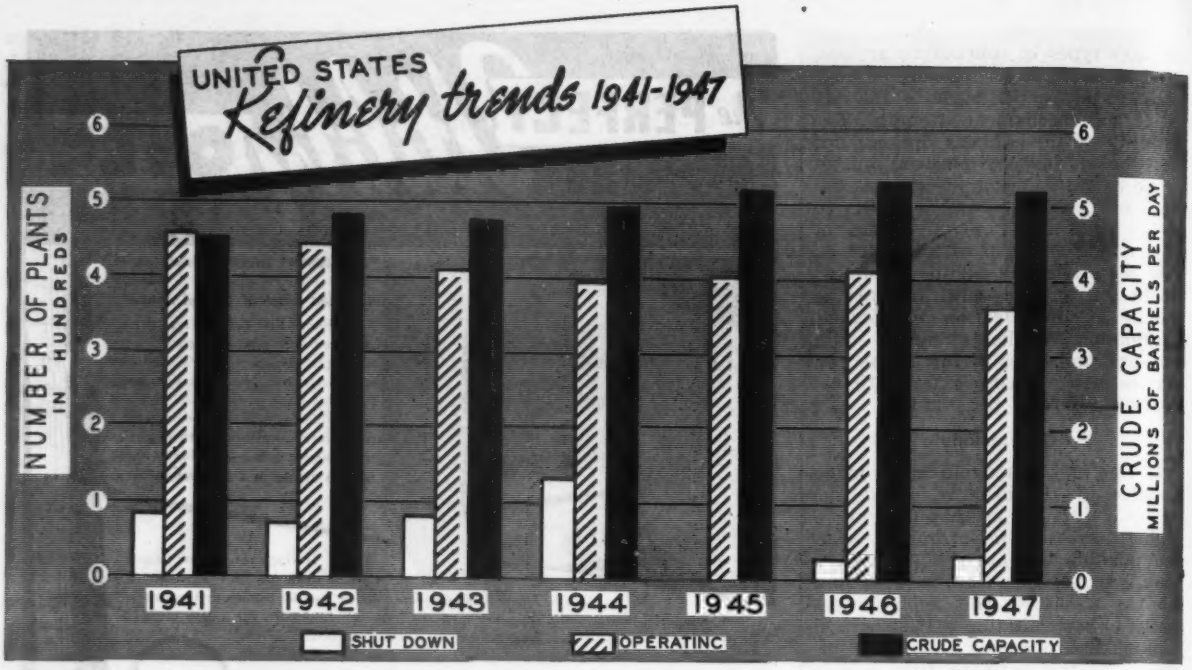

Status of operating and shutdown refineries and total crude charging capacity, 1941-47

"Average" Refinery Growing Bigger and Bigger

THE crude-processing capacity of that mythical "average" refinery in the United States is growing with a fair degree of rapidity, a study of the 1947 annual refinery survey compiled by the statistical department of the Journal shows. With a decided drop in the total number of refineries operating or in operable condition, from 436 in 1946, including a number whose status was very uncertain at the time of that survey, to a total of operating and shutdown plants as of January 1, 1947, the average crude-charging capacity rose from 12,800 to almost 14,000 (13,907) bbl. The 365 operating plants divided a crude capacity of nearly 5,400,000 bbl., ranging in individual plants from less than 100 bbl. per day to 192,000 bbl. as reported for the huge Gulf plant at Port Arthur, Tex. Humble Oil & Refining Co. is second with 190,000 bbl. per day reported capacity, with Standard of New Jersey at Baton Rouge third with 180,000 bbl.

The largest cracking capacity reported is The Texas Co. at Port Arthur, with 166,500 bbl. per day of charge capacity; Humble at Baytown is second with 142,200 bbl. per day. Total crude-charge increase is practically 131,000 bbl. per day.

Cracking capacities of active plants show a healthy increase of 280,000 bbl. per day. Practically all this is traceable to the increase in catalytic cracking capacity, although a number of thermal crackers have been revamped to give added throughputs.

The heavy drop in total number of plants is due almost entirely as stated, to the complete elimination of a number of small plants with one or two larger ones, by dismantling, moving or other means which take them out of the list of existing refinery facilities. These are not included in either column, but it may be possible to publish later a resume of these plants, to clarify the record finally as to their disposal.

TRENDS IN NUMBER OF REFINERIES, TOTAL REFINING CAPACITY, AND AVERAGE PER PLANT, 1940-47

Year—	No. of refineries: Operating	No. of refineries: Shutdown	Crude capacity: Total	Crude capacity: Operating	Average refinery capacity
1940	462	70	4,665,318	4,438,658	9,600
1941	459	89	4,816,715	4,524,775	9,850
1942	445	74	5,039,815	4,793,635	10,800
1943	412	84	5,043,010	4,780,025	11,600
1944	394	129	5,232,550	4,977,400	12,650
1945	401	(*)	(*)	5,192,700	13,000
1946	411	25	5,431,995	5,288,600	12,860
1947	365	35	5,562,825	5,399,280	13,907

*1945 shutdown capacity uncertain.

While not shown separately in the survey, the trend in catalytic cracking capacity is strongly upward, as indicated by the individual reports showing operating, building, and planned units of these types. These figures, all confidential except operating capacities already announced and known, show that at least 125,000 bbl. per day of catalytic cracking capacity is planned or "on the boards" for starting construction during 1947, divided among some 10 or more units. Unconfirmed rumors indicate that a number of other plants are strong possibilities. In addition, between 20,000 and 25,000 bbl. per day of catalytic reforming capacity is reported, divided among several plants of most of which the exact capacity to be built has not been determined. Obviously refiners of large and of small degree are trimming their sails for more speed in antiknock production in the future, to accentuate competition for the nation's gallonage as the number of new cars increases and older, more decrepit cars pass off the highway.

Additional refinery building is projected, to the extent of more than 50 units of various types. Five thermal crackers and/or reformers are planned, only half the number of catalytic units projected. The remaining number of new units include a half-dozen lubricating-oil plants, some new, some expansions of existing equipment. One company, Union Oil Co. of California, is extending its lubricant capacity by 300 per cent, according to statements issued.

NORTH AMERICAN OPERATING REFINERIES

Their Capacities and Locations

Compiled by the Statistical Department of The Oil and Gas Journal

SUMMARY OF ACTIVE PLANTS IN THE UNITED STATES

	No. plants	Barrels daily: Crude-oil capacity	Barrels daily: Cracking capacity
Alabama	1	3,500	.....
Arkansas	7	51,500	14,400
California	53	939,050	593,300
Colorado	7	15,000	7,490
Delaware	1	3,500	.....
Georgia	1	4,000	.....
Idaho	1	2,100	530
Illinois	16	296,100	192,430
Indiana	8	265,750	145,800
Kansas	18	193,350	128,225
Kentucky	6	54,000	30,600
Louisiana	13	334,350	202,525
Maryland	3	57,400	31,800
Massachusetts	2	39,000	17,500
Michigan	17	101,500	39,350
Minnesota	2	6,000	.....
Mississippi	2	6,500	1,000
Missouri	1	26,500	18,500
Montana	10	40,400	19,050
Nebraska	5	5,350	650
New Jersey	6	279,900	155,000
New Mexico	8	13,150	4,850
New York	7	88,800	42,000
Ohio	10	217,000	222,200
Oklahoma	25	222,600	114,900
Pennsylvania	22	434,800	278,110
Rhode Island	3	16,900	1,500
South Carolina	1	7,000	.....
Tennessee	2	5,500	1,500
Texas	77	1,545,300	1,051,550
Utah	4	23,400	16,100
Washington	1	6,000	2,500
West Virginia	3	12,000	17,650
Wisconsin	1	5,000	.....
Wyoming	21	77,080	37,450
Total	365	5,399,280	3,388,460

EXPLANATION OF ABBREVIATIONS

Cracking capacity is based on daily capacity to produce cracked gasoline. In a few cases companies reported raw-charging capacity.

(Comp.)—Complete plant, gasoline, kerosene, gas oil, fuel oil, lubricating oils, paraffin, wax, and asphalt, usually includes cracking.

(S)—Gasoline, kerosene distillate, gas oil, and fuel oil.

(L)—Lubricating oils.

(A)—Asphalt.

(C)—Same products as skimming, except plants are equipped with cracking.

(W)—Wax.

ALABAMA

Company and plant location—	Crude oil cap. bbl.	Cracking cap. bbl.	Type of refinery
Placid Oil Co., Tuscaloosa	3,500	.....	S-A

ARKANSAS

Company and plant location—	Crude oil cap. bbl.	Cracking cap. bbl.	Type of refinery
Berry Asphalt Co., Stephens	2,500	.....	S-A
Waterloo	1,500	.....	S-L-A
Cross, Henry H., & Co., Smackover	6,000	.....	S-L-A
Lion Oil Co., El Dorado	20,000	†2,000	C-L-A
MacMillan Pet. Corp., Norphlet	3,500	.....	S-L
Root Pet. Co., El Dorado[1]	15,500	†12,400	C
Stephens Ref. Co., Inc., Stephens	2,500	.....	S
Total	51,500	14,400	

CALIFORNIA

Company and plant location—	Crude oil cap. bbl.	Cracking cap. bbl.	Type of refinery
Aromalene, Inc., Long Beach	1,500	.....	S
Ben Hur Ref. Co., Long Beach	3,000	.....	S
Calstate Ref. Co., Long Beach	.....	2,000	C
Caminol Co., Ltd. Hanford	3,100	600	C
Santa Fe Springs	3,500	1,100	C
Century Oil Co., Long Beach	5,000	.....	S
Douglas Oil Co. of Calif., Bakersfield	5,500	3,000	C
Clearwater	3,500	.....	S-A
Eagle Oil & Ref. Co., Inc., Santa Fe Springs	5,000	1,500	C
Economy Asphalt Co., Oxnard	600	.....	A
Edgington Oil Refinery, Long Beach	2,500	.....	A
Envoy Pet. Co., Long Beach	4,000	.....	S-A
Exeter Ref. Co., Long Beach	10,000	.....	S-A
Five C Refining Co., Santa Maria	3,000	.....	S-A
Fletcher Oil Co., Wilmington	3,500	†1,200	C-A
General Pet. Corp., Lebec	23,000	.....	S
Torrance[2]	90,000	74,000	C
Vernon	2,000	.....	S-A
Hancock Oil Co. of Calif., Long Beach	12,500	6,500	C
Harbor Ref. & Trans. Co., Long Beach	2,500	.....	S
Lunday-Thagard Oil Co., South Gate	750	.....	A
MacMillan Pet. Corp., Long Beach	7,500	.....	S
McCallen Ref. Co., Ltd., Huntington Beach	5,000	.....	S
Mohawk Pet. Corp., Bakersfield	7,800	†4,500	C
Newhall Ref. Co., Newhall	3,000	.....	S-A
Norwalk Co., The, Maricopa	12,000	.....	S
Pacific Coast Asphalt Co., Oxnard	400	.....	A
Pacific States Oil Co., Wilmington	25,000	.....	S
Palomar Ref. Co., Bakersfield	1,300	.....	S-L-A
Petrol Corp., The, Los Angeles	6,000	.....	S-A
Richfield Oil Co., Wilmington[2]	80,000	63,000	Comp.
Rothschild Oil Co., Santa Fe Springs	5,500	1,400	C
Seaside Oil Co., Ventura	4,500	.....	S-A
Shell Oil Co., Inc., Coalinga	6,700	.....	S
Martinez	45,000	26,000	Comp.
Wilmington[1]	52,000	52,000	C
Socal Oil & Ref. Co., Huntington Beach	2,500	1,350	C
Standard Oil Co. of Calif., Bakersfield	25,000	.....	S-A
El Segundo[2]	100,000	71,450	Comp
Richmond	100,000	68,500	Comp.
Sunland Ref. Corp., Bakersfield	2,000	.....	S
Sunray Oil Corp., Santa Maria	7,500	4,000	C-A
Sunset Oil Co., Torrance	4,500	.....	S
Texas Co., The, Fillmore	4,000	†3,600	C
Los Angeles[1]	45,000	32,000	C

SYMBOLS OF PROGRESS

Progress is measured by industry's know-how and ability to design, manufacture and distribute.

The Continental organization, through its strategically located group of outlets, is properly geared to supply its customers with equipment produced by its recognized representative manufacturers. Men of the oil country know the "Green Triangle" as a symbol of *quality* equipment and *good* service.

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Company and plant location—	Crude oil cap. bbl.	Cracking cap. bbl.	Type of refinery
CALIFORNIA (continued)			
Tide Water Associated Oil Co., Avon[1]	60,900	†51,400	Comp.
Wilmington	14,000	8,200	C
Triangle Oil & Ref. Co., Venice	2,500	.....	S
Union Oil Co. of Calif., Bakersfield	8,500	.....	S-A
Oleum[4]	45,000	†44,000	Comp.
Wilmington[2]	50,000	66,000	C-A
Western Asphalt & Ref. Co., Santa Maria	1,500	.....	S-A
Wilshire Oil Co., Inc., Norwalk	20,000	†6,000	C
Total	939,050	593,300	
COLORADO			
Bay Pet. Corp., Denver	5,000	†1,900	C
Continental Oil Co., Denver	3,200	1,500	C
Gordon Ref. Co., Fort Morgan	200	.....	S
Oriental Ref. Co., Alamosa	1,100	900	C
Denver	1,500	1,000	C
Perry Pet. Co., Denver	1,000	190	C
Texas Co., The, Craig	3,000	2,000	C
Total	15,000	7,490	
DELAWARE			
Texas Co., The, Claymont	3,500	.....	A
GEORGIA			
Mexican Pet. Corp. of Ga., Savannah	4,000	.....	S-A
IDAHO			
Idaho Ref. Co., Pocatello	2,100	530	C
ILLINOIS			
Advance Ref. Co., Centralia	2,500	.....	S
Calumet Ref. Co., Burnham	1,100	.....	S-L
Cross, Henry H., Co., Colmar	1,000	.....	S
Dupo	1,000	.....	S
Globe Oil & Ref. Co., Lemont	27,000	†5,500	C
Great Lakes Ref. Co., Blue Island	7,000	2,000	C
Ohio Oil Co., The, Robinson	15,000	†9,000	C-A
Pana Ref. Co., Pana	4,000	1,750	C
Red River Ref. Co., Burnham	1,100	.....	S
Shell Oil Co., Inc., Wood River[1]	91,000	†49,000	Comp.
Socony-Vacuum Oil Co., Inc., East St. Louis[2 3]	21,000	27,180	Comp.
Standard Oil Co. (Ind.), Wood River[1]	31,000	27,500	Comp.
Texas Co., The, Lawrenceville	27,000	†17,000	Comp.
Lockport[1]	50,000	†48,500	Comp.
Wireback Oil Co., Plymouth	400	.....	S
Wood River Oil & Ref. Co., Inc., Hartford	16,000	†5,000	C-A
Total	296,100	192,430	
INDIANA			
Cities Service Oil Co. (Del.), East Chicago	30,000	†18,000	Comp.
Indiana Farm Bur. Coop. Assn., Inc., Mount Vernon	4,100	†2,500	C
Johnson Oil Supply Co., Gary	2,500	.....	S
Rock Island Ref. Corp., Rock Island	7,000	†4,800	C-A
Sinclair Ref. Co., East Chicago	55,000	†30,000	Comp.
Socony-Vacuum Oil Co., Inc., East Chicago[3]	34,500	20,500	C
Standard Oil Co. (Ind.), Whiting[1]	132,000	†70,000	Comp.
Troy Ref. Corp., Troy	650	.....	S
Total	265,750	145,800	
KANSAS			
Bareco Oil Co., Wichita	7,000	†3,200	C
Bay Pet. Corp., McPherson	6,000	†3,300	C
Chanute Ref. Co., Chanute	1,000	1,000	C
Coop. Refinery Association,* Coffeyville	13,500	†5,250	C-L-W
Phillipsburg	4,000	†2,100	C
Derby Oil Co., Wichita	8,000	†4,200	Comp.
El Dorado Ref. Co., El Dorado	8,000	4,000	C
Kanotex Ref. Co., Arkansas City	9,000	†4,500	C-A
M. F. A. Oil Co., Chanute	1,650	1,000	C
Natl. Coop. Refinery Association, McPherson	18,000	28,000	C
Phillips Pet. Co., Kansas City	29,000	†22,000	C
Shallow Water Ref. Co., Shallow Water	2,500	550	C
Sinclair Ref. Co., Coffeyville	11,000	†7,000	Comp.
Kansas City	12,000	†7,000	C
Skelly Oil Co., El Dorado	25,000	†8,000	C-A
Socony-Vacuum Oil Co., Inc., Augusta[3]	25,000	19,900	C-A
Standard Oil Co. (Ind.), Neodesha	7,700	4,600	C
Vickers Pet. Co., Potwin	5,000	2,625	C
Total	193,350	128,225	
KENTUCKY			
Aetna Oil Co., Louisville	8,000	4,500	C
Ashland Oil & Refining Co., Catlettsburg[3]	22,000	15,000	Comp.
Louisville Ref. Co., Louisville	6,500	†2,500	C
Somerset Refinery, Somerset	500	.....	S
Standard Oil Co. (Ohio), Covington	15,000	†8,600	C-A
Stoll Oil Ref. Co., Louisville	2,000	.....	S-L-W
Total	54,000	30,600	
LOUISIANA			
Atlas Oil & Ref. Co., Shreveport	12,000	†6,000	S-C
Bayou State Oil Corp., Hosston	800	.....	S-L-A
Calumet Ref. Co., Princeton	700	.....	S
Chalmette Pet. Corp., Chalmette	10,000	†6,000	C
Cities Service Ref. Corp., Lake Charles[1]	70,000	59,750	C
Continental Oil Co., Lake Charles	9,500	†5,600	C
Evangeline Ref. Co., Jennings	1,000	.....	S-L
Pan American Ref. Corp., Destrehan	7,500	.....	S-A
Petco Corp., Marrero	3,500	2,000	C
Shell Oil Co., Inc., Norco	35,000	†21,300	C-A
Southern States Ref., Inc., Eola	800	.....	S
Standard Oil Co. of N. J., Baton Rouge	180,000	99,500	Comp.
Stanolind Oil & Gas Co., Vivian	3,550	2,375	C
Total	334,350	202,525	
MARYLAND			
American Bitumuls, Baltimore	2,400	.....	S-A
Pan American Ref. Corp., Baltimore	8,000	.....	S-A
Standard Oil Co. of N. J., Baltimore[1]	47,000	31,800	C-L-A
Total	57,400	31,800	
MASSACHUSETTS			
Cities Service Oil Co. (Pa.), E. Braintree	6,000	.....	S-A
Colonial Beacon Oil Co., Everett	33,000	†17,500	C-A
Total	39,000	17,500	
MICHIGAN			
Aurora Gasoline Co., Detroit[1]	8,000	†7,500	C-A
Elsie	4,000	.....	S
Bay Ref. Corp., Bay City	10,500	.....	S
Crystal Ref. Co. of Carson City, Inc., Carson City	6,200	.....	S
Lakeside Ref. Co., Kalamazoo	1,700	.....	S
Leonard Refineries, Inc., Alma[2]	8,000	6,000	C-A
Louis Rose Ref. Co., Saginaw	1,000	.....	S
Marvel Ref. Co., Grand Rapids	2,000	.....	S
Mid-West Refineries, Inc., Alma	4,000	†1,850	C
Naph-Sol Ref. Co., Muskegon	5,000	2,500	C
Old Dutch Ref. Co., Muskegon	4,500	†2,000	C
Osceola Ref. Co., Reed City	2,000	.....	S
Petroleum Specialties, Inc., Flat Rock	3,000	1,000	C
Producers Ref., Inc., West Branch	1,000	.....	S-A
Pure Oil Co., Midland	5,500	.....	S
Roosevelt Oil Co., Mount Pleasant	5,000	.....	S
Socony-Vacuum Oil Co., Inc., Trenton[3]	30,100	18,500	C
Total	101,500	39,350	
MINNESOTA			
Comet Refinery Co., New Brighton	1,000	.....	S
Northwestern Ref. Co., St. Paul Park	5,000	.....	S-A
Total	6,000	.....	
MISSISSIPPI			
Paluxy Asphalt Co., Yazoo City	3,500	1,000	C-A
Southland Oils, Inc., Sandersville	3,000	.....	S-A
Total	6,500	1,000	
MISSOURI			
Standard Oil Co. (Ind.), Sugar Creek[1]	26,500	†18,500	Comp.
MONTANA			
Big West Oil Co., Kevin	1,500	1,000	C
Carter Oil Co., Billings	10,000	900	C-A
Cut Bank	4,000	†2,000	C
Farmers Union Central Exchange, Inc., Laurel	8,800	†5,200	C-A
Hole Brothers Refinery, Cut Bank	350	.....	S
Home Oil & Ref. Co., Great Falls	2,250	†1,250	C-A
Texas Co., The, Sunburst	7,500	6,000	C
Treasure State Ref. Co., Shelby	500	.....	S
Union Oil Co. of Calif., Cut Bank	4,500	†2,700	C
Unity Pet. Corp., Kalispell	1,000	.....	S
Total	40,400	19,050	
NEBRASKA			
Coop. Refinery Association, Scottsbluff	1,500	650	C
Oil Marketing & Ref., Inc., Salem	800	.....	S
Petroleum Utilities, Inc., Chadron	750	.....	S
Porter Oil Co., Sidney	300	.....	S
Searle Pet. Co., Salem	2,000	.....	S
Total	5,350	650	

NEW JERSEY

Company and plant location—	Crude oil cap. bbl.	Cracking cap. bbl.	Type of refinery
California Ref. Co., Perth Amboy	15,000	4,000	C-A
Cities Service Oil Co. (Pa.), Linden	12,000	.....	S-A
Petty's Island	9,000	.....	S-A
Socony-Vacuum Oil Co., Inc., Paulsboro[2 3]	38,900	27,500	Comp.
Standard Oil Co. of N. J., Linden[1]	135,000	†91,000	Comp.
Tide Water Associated Oil Co., Bayonne[3]	70,000	32,500	Comp.
Total	279,900	155,000	

NEW MEXICO

Aerex Co., Bloomfield	100	.....	S
Continental Oil Co., Artesia	2,000	1,250	C
Farmington	750	.....	S
Malco Refineries, Inc., Roswell	2,000	1,000	C
McNutt Oil & Ref. Co., Brickland	2,200	600	C
New Mexico Asphalt & Ref. Co., Artesia	4,000	2,000	C
Petroleum Products Ref. & Prod., Prewit	1,500	.....	S
Warren Pet. Corp., Monument	600	.....	S
Total	13,150	4,850	

NEW YORK

Allegany Refiners, Inc., Bolivar	1,500	.....	S-L
Frontier Oil Ref. Co., Tonawanda	8,500	2,500	C
Gulf Oil Corp., Staten Island	16,000	.....	S
Sinclair Ref. Co., Wellsville	11,000	6,000	Comp.
Socony-Vacuum Oil Co., Inc., Brooklyn[3]	21,300	18,000	Comp.
Buffalo[3]	23,500	15,500	Comp.
Olean	7,000	.....	L-W
Total	88,800	42,000	

OHIO

Canton Ref. Div. of Central Pipe Line Co., Canton	8,500	2,000	C
Gulf Ref. Co., Cleves	26,600	14,000	C
Toledo	23,000	10,000	C
National Ref. Co., Findlay	9,000	5,000	Comp.
Pure Oil Co., Newark	15,500	36,200	C
Toledo	29,400	61,100	C
Standard Oil Co. (Ohio), Cleveland[3]	38,000	41,000	Comp.
Lima	12,000	†6,900	C
Toledo	20,000	†15,000	Comp.
Sun Oil Co., Toledo[3]	35,000	†31,000	C
Total	217,000	222,200	

OKLAHOMA

Allied Materials Corp., Stroud	1,500	.....	S-A
Anderson-Prichard Ref. Corp., Cement	2,500	.....	S
Cyril	10,000	5,000	C-A
Bareco Oil Co., Barnsdall	.....	.....	W
Bell Oil & Gas Co., Granfield	4,500	2,500	C
Ben Franklin Ref. Co., Ardmore	4,500	†2,500	C
Champlin Ref. Co., Enid	18,000	9,000	C-L-W
Cities Service Oil Co. (Del.), Ponca City	11,000	4,500	C-L-W
Continental Oil Co., Ponca City[3]	26,000	†24,250	Comp.
Deep Rock Oil Corp., Cushing	12,000	†5,000	Comp.
Denver Prod. & Ref. Co., Edmond	2,000	.....	S
Fen-Ter Ref. Co., Wynnewood	5,000	1,300	C-A
Johnson Oil Ref. Co., Cleveland	5,500	2,750	S
Mercury Oil Ref. Co., Oklahoma City	2,000	1,200	C
Mid-Continent Pet. Corp., West Tulsa	40,000	†20,000	Comp.
Midland Coop. Wholesale, Cushing	4,000	1,800	C
Monarch Refineries, Inc., Oklahoma City	600	400	C-A
Peppers Ref. Co., Oklahoma City	1,500	300	C
Phillips Pet. Co., Okmulgee	8,000	†2,500	C-L
Rock Island Ref. Co., Duncan	8,000	2,500	C-A
Sinclair Ref. Co., Sand Springs	7,000	3,000	Comp.
Sunray Oil Corp., Allen	12,000	†7,000	C-A
Texas Co., The, West Tulsa	20,000	†12,000	Comp.
Tide Water Associated Oil Co., Drumright	12,000	†5,000	C
Wilcox Oil Co., Bristow	5,000	†2,400	C
Total	222,600	114,900	

PENNSYLVANIA

Atlantic Ref. Co., Philadelphia[1]	100,000	†71,600	Comp.
Canfield Oil Co., Coraopolis	1,000	.....	S-L
Cities Service Oil Co. (Pa.), Titusville	3,000	.....	S-L-W
Continental Ref. Co., Oil City	1,000	400	Comp.
Daugherty Refinery (L. Sonneborn Sons), Petrolia	4,000	.....	S-L-W
Franklin Refinery Div. of L. Sonneborn Sons, Inc., Franklin	2,000	.....	S-L
Freedom-Valvoline Oil Co., Butler	2,500	.....	S-L-W
Freedom	4,000	†1,050	C-L-W
Gulf Oil Corp., Neville Island[1]	14,500	6,000	C
Philadelphia	68,000	41,000	C-L
Kendall Ref. Co., Bradford	5,000	2,200	Comp.
Pennzoil Co., The, Rouseville[1]	8,500	†7,800	Comp.
Quaker State Oil Ref. Corp., Emlenton	2,000	1,350	Comp.
Farmers Valley	4,000	1,350	Comp.
Oil City	2,800	1,600	Comp.
Sherwood Ref. Co., Inc., Warren	1,000	.....	S-L-W
Karns City	1,000	.....	S-L-W
Sinclair Ref. Co., Marcus Hook	65,000	†40,000	C
Sun Oil Co., Marcus Hook[3]	135,000	101,000	Comp.
United Ref. Co., Warren	5,500	†2,000	Comp.
Waverly Oil Works Co., Pittsburgh	2,500	.....	S-L-W
Wolf's Head Oil Ref. Co., Inc., Reno	2,500	960	Comp.
Total	434,800	278,110	

RHODE ISLAND

American Bitumuls, E. Providence	1,400	.....	S-A
Socony-Vacuum Oil Co., Inc., Riverside	12,000	1,500	C-A
Texas Co., The, Providence	3,500	.....	A
Total	16,900	1,500	

SOUTH CAROLINA

Standard Oil Co. of N. J., Charleston	7,000	.....	A

TENNESSEE

Delta Ref. Co., Memphis	4,500	1,500	C-A
Southern Oil Service, Nashville	1,000	.....	S
Total	5,500	1,500	

TEXAS

American Mineral Spirits Co., Corpus Christi	10,000	.....	S
Atlantic Ref. Co., Port Arthur[1]	27,000	†30,000	C
Baird Ref. Co., Baird	2,500	1,200	C
Bryson P. L. & Ref. Co., Bryson	1,500	250	C
Clymore Co., Inc., Pettus	1,300	.....	S
Coastal Refineries, Inc., Port Isabel	7,000	2,500	C
Col-Tex Ref. Co., Colorado City	10,000	4,000	C-A
Consumers Coop. Ref. Assn., Levelland	5,200	2,600	C
Continental Oil Co., Wichita Falls	5,000	†3,900	C
Cosden Pet. Corp., Big Spring	18,000	†12,250	C
Crown Central Pet. Corp., Houston	20,000	8,500	C-L
Danaho Ref. Co., Pettus	2,000	500	C
Eastern States Pet. Co., Houston, Plant 1	30,000	12,000	C-A
Plant 2[1]	.....	5,000	C
Eddy Ref. Co., Houston	2,000	.....	S
Gladewater Ref. Co., Gladewater	2,500	1,000	C
Graytex Ref. Co., Graham	300	.....	S-L
Great Southern Corp., Corpus Christi	.....	4,000	C
Gulf Oil Corp., Fort Worth	7,200	4,000	C
Port Arthur[2 3]	192,000	†98,000	Comp.
Sweetwater	10,000	4,000	C
Hamman Oil & Ref. Co., Bay City	2,300	.....	S-W
Humble Oil & Ref. Co., Baytown[1]	190,000	†142,200	Comp.
San Antonio	7,000	.....	S
Hutex Oil & Ref. Co., Hardin	1,000	.....	S
Independent Ref. Co., Arp	2,000	.....	S
Inland Ref. Co., Palestine	2,000	.....	S
La Salle Pet. Corp., Burkburnett	2,500	.....	S
Magnolia Pet. Co., Beaumont[2 3]	125,000	†100,200	Comp.
Fort Worth	12,000	†11,100	C
Maritime Oil Co., Houston	5,000	.....	S
Master Pet. Co., Dallas	2,000	.....	S-L-A
McBride Ref. Co., La Blanca	2,000	.....	S-L-A
McMurrey Ref. Co., Tyler	9,000	4,500	C
Nueces Ref. Co., Clarkwood	2,500	.....	S
Onyx Ref. Corp., Abilene	3,000	800	C
Pan American Ref. Corp., Texas City[1]	100,000	†60,000	C
Panhandle Ref. Co., Lueders	1,500	750	C
Wichita Falls	4,000	†1,800	C
Patton Oil Co., Rotan	900	.....	S
Payward Ref. Co., Shamrock	700	.....	S
Phillips Pet. Co., Borger[4]	44,000	†46,000	C
Pampa	7,000	†3,500	C
Pioneer Oil & Ref. Co., Somerset	800	.....	S-A
Pontiac Ref. Corp., Corpus Christi	20,000	.....	S
Premier Oil Ref. Co., Longview	4,500	3,000	C
Fort Worth	5,500	3,000	C-L-W
Prichard Ref. Co., San Antonio	1,500	.....	S
Pure Oil Co., Nederland[2]	55,000	†98,000	C
Rado Ref. Co., McAllen	1,000	.....	S
Refugio Refinery, Refugio	1,500	.....	S
Republic Oil Ref. Co., Texas City[1]	28,000	22,000	C
Shamrock Oil & Gas Corp., Sunray	6,000	4,000	C
Shell Oil Co., Inc., Houston[1]	85,000	65,000	C
Sid Richardson Ref. Co., Texas City	18,500	2,000	C
Sinclair Ref. Co., Corpus Christi[3]	27,000	20,000	C
Fort Worth	6,500	4,500	C
Houston[2 3]	73,000	62,000	Comp
Skelly Oil Co., Longview	9,000	2,700	C
Southwestern Oil & Ref. Co., Corpus Christi	18,000	.....	S
Standard Oil Co. of Texas, El Paso	14,000	5,000	C

TEXAS (Continued)

Company and plant location—	Crude oil cap. bbl.	Cracking cap. bbl.	Type of refinery
Stone Oil Co., Texas City	7,500	.....	S
Talco Asphalt & Ref. Div. of Am. Liberty Oil, Mount Pleasant	12,000	2,000	C
Taylor Ref. Co., Taylor, Tex.	22,500	3,800	C
Texas Co., The, Amarillo	7,500	4,000	C
El Paso	4,000	2,000	C
Houston	27,500	.....	S
Port Arthur[1]	135,000	†166,500	Comp
Port Neches	40,000	.....	S-A
San Antonio	7,000	6,000	C
West Dallas	15,000	†9,000	C
Three Rivers Refinery, Three Rivers	1,500	.....	S-L-A
Tydal Ref. Co., Gainesville	1,500	.....	S
United Gas Pipe Line Co., Beeville	600	.....	S
Uvalde Rock Asphalt Co., Blewett	500	.....	S
Waggoner, W. T., Estate, Electra	7,000	†2,500	C
Wickett Ref. Co., Wickett	2,500	.....	S
Total	1,545,300	1,051,550	

UTAH

Tri-State Oil & Ref. Co., Relico	500	.....	S
Uinta Oil Ref. Co., Jensen	500	.....	S
Utah Oil Ref. Co., Salt Lake City[1]	20,000	14,400	Comp.
Wasatch Oil Ref. Co., Woods Cross	2,400	†1,700	C-A
Total	23,400	16,100	

WASHINGTON

Inland Empire Refineries, Inc., Hillyard	6,000	2,500	C-A

WEST VIRGINIA

Elk Ref. Co., Falling Rock	4,000	†2,000	Comp.
Pure Oil Co., Cabin Creek	5,500	†14,300	C-L-W
Quaker State Oil Ref. Corp., St. Marys	2,500	1,350	Comp.
Total	12,000	17,650	

WISCONSIN

Wisconsin Oil Ref. Co., Inc., Sheboygan	5,000	.....	S

WYOMING

Carter Oil Co., Lovell	3,000	.....	S-A
Newcastle	1,600	900	C
Continental Oil Co., Glenrock	3,400	†1,900	C
Crook County Refinery, Sundance	125	.....	S
Elk Horn Gas Refinery, Osage	55	.....	S
Empire State Oil Co., Thermopolis	3,000	.....	S-A
Frontier Ref. Co., Cheyenne[1]	7,500	†4,000	C-A
Gray Refinery, Inc., Newcastle	1,500	.....	S
Husky Ref. Co., Cody	5,000	.....	S-A
Manewal-Bradley Oil Co., Inc., Osage	400	.....	S
Ohio Oil Co., The, Lovell	5,000	.....	S-A
Pilot Oil Co., Morton	500	200	C
Resolute Oil Corp., Badger Basin	1,000	.....	S
Sinclair Ref. Co., Sinclair[1]	14,000	13,000	C-A
Socony-Vacuum Oil Co., Inc., Casper	4,500	1,600	C-A
Standard Oil Co. (Ind.), Greybull	5,500	1,900	Comp.
Standard Oil Co. (Ind.), Casper	13,000	6,350	Comp.
Texas Co., The, Calpet	400	.....	S
Casper	7,000	†7,600	C
Tri-State, Inc., Thermopolis	500	.....	S-A
Z & W Service & Refinery, Torrington	100	.....	S
Total	77,080	37,450	

(1) Fluid catalytic cracking included in cracking capacity.
(2) Thermofor catalytic cracking included in cracking capacity.
(3) Houdry catalytic cracking included in cracking capacity.
(4) Cycloversion cat. cracking included in cracking capacity.

OPERATING REFINERIES IN CANADA

ALBERTA

British-American Oil Co., Ltd., Calgary	5,000	2,500	C-A
Gas & Oil Refineries, Ltd., Hartell	2,000	†1,000	C
Imperial Oil, Ltd., Calgary	9,500	4,000	C-A
Total	16,500	7,500	

BRITISH COLUMBIA

Imperial Oil, Ltd., Ioco	12,000	3,200	Comp.
Shell Oil Co. of B. C., Shelburn	4,200	.....	S
Standard Oil Co. of B. C., Ltd., Vancouver	5,000	.....	S-A
Total	21,200	3,200	

MANITOBA

Anglo-Canadian Oils, Ltd., Brandon	2,200	1,000	C
North Star Oil, Ltd., St. Boniface	2,000	750	C
Radio Oil Ref., Ltd., Winnipeg	700	.....	S
Total	4,900	1,750	

NEW BRUNSWICK

Company and plant location—	Crude oil cap. bbl.	Cracking cap. bbl.	Type of refinery
New Brunswick Gas & Oilfields, Ltd., Weldon	300	.....	S

NORTHWEST TERRITORIES

Imperial Oil, Ltd., Norman Wells	1,100	.....	S
Northwest Co., Ltd., Fort Norman	850	.....	S
Total	1,950	.....	

NOVA SCOTIA

Imperial Oil, Ltd., Imperoyal	34,000	9,000	C-A

ONTARIO

British-American Oil Co., Ltd., Clarkson	8,300	4,400	C-A
Toronto	6,000	3,000	C
Burlington Refineries, Ltd., Hamilton	600	.....	S
Canadian Oil Companies, Ltd., Petrolia	4,000	†4,000	C
Goodrich Ref. Co., Ltd., Port Credit	4,000	3,000	C
Imperial Oil, Ltd., Sarnia	46,000	28,000	Comp.
McColl-Frontenac Oil Co., Ltd., Toronto	12,000	†7,000	C
Total	80,900	49,400	

QUEBEC

British-American Oil Co., Ltd., Montreal East	12,000	7,500	C-A
Imperial Oil, Ltd., Montreal East	25,000	10,700	C-A
McColl-Frontenac Oil Co., Ltd., Montreal	24,000	†14,400	C
Shell Oil Co. of Canada, Ltd., Montreal East	10,000	6,500	C
Total	71,000	39,100	

SASKATCHEWAN

British-American Oil Co., Ltd., Moose Jaw	4,000	2,000	C-A
Hi-Way Refineries, Ltd., Moose Jaw	350	.....	S
Rosetown	400	.....	S
Saskatoon	500	.....	S
Husky Ref. Co., Lloydminster	2,500	.....	S-A
Imperial Oil, Ltd., Regina	10,500	†6,300	C-A
Northern Pet. Corp., Ltd., Kamsack	400	.....	S-L
Saskatchewan Federated Cooperatives, Ltd., Regina	2,000	1,000	C
Sterling Ref., Ltd., Yorkton	750	250	C
Total	21,400	9,550	

REFINERIES IN MEXICO

Petroleos Mexicanos, Arbol Grande, Tamp.	23,000	.....	L-W-A
Atzcapotzalco, D. F.	50,000	13,500	C
Ciudad Madero, Tamp.	57,000	4,900	Comp.
Minatitlan, Ver.	28,000	.....	S-L
Poza Rica, Ver.	7,500	.....	S
Villa Cuauhtemoc, Ver.	13,400	9,300	C
Total	178,900	27,700	

SHUTDOWN PLANTS IN CANADA

Abasand Oils, Ltd., Fort McMurray, Alta.	800	600	C-A
Diana Oil & Ref. Co., Lloydminster, Sask.	250	.....	S
Lion Ref. Co., Calgary, Alta.	(*)	(*)	
Home Oil Distributors, N. Vancouver, B. C.	2,000	.....	S-L
Total	3,050	600	

*Capacities not reported.

SHUTDOWN PLANTS IN THE U.S.

CALIFORNIA

Field, O. C., Gasoline Corp., Casmalia	4,000	.....	S-A
Harbor Terminal Oil Co., Wilmington	3,000	.....	S
Olympic Ref. Co., Long Beach	6,500	.....	S
Operators Oil & Ref. Co., Long Beach	5,000	.....	S
Richfield Oil Corp., Bell	10,000	4,500	C
Total	28,500	4,500	

COLORADO

Company and plant location—	Crude oil cap. bbl.	Cracking cap. bbl.	Type of refinery
Raven Oil & Ref. Co., Rangely	115	.....	S
ILLINOIS			
Allied Oil Corp., St. Elmo	5,000	2,200	C
Cascade Ref. Co., Selmaville	2,600	590	C
Total	7,600	2,790	
KANSAS			
Anco Ref. Co., Garnett	550	.....	S
H & T Reclaiming & Ref. Co., Chase	2,000	.....	S
Total	2,550	.....	
KENTUCKY			
Ashland Oil & Ref. Co., Pryse	5,000	2,000	C
LOUISIANA			
Arkansas Fuel Oil Co., Bossier City	28,000	14,000	C
Coast Oil Co., Cotton Valley	1,500	.....	S
Ohio Farm Bureau Co-op., Meraux	3,200	.....	S
Premier Oil Ref. Co. of Texas, Cotton Valley	5,000	.....	S
Total	37,700	14,000	
MICHIGAN			
Mid-West Refineries, Inc., Grandville	4,500	2,000	C
MONTANA			
Big Lake Oil Co., Lake Basin	80	.....	S
Gallatin Farmers Co., Belgrade	240	.....	S
Hunt, D. Eugene, Winnett	300	.....	S
North American Oil & Ref. Co., Chinook	300	.....	S
Patterson, H. F., Ref. Co., Sweet Grass	800	.....	S
Total	1,720	.....	

NEBRASKA

Company and plant location—	Crude oil cap. bbl.	Cracking cap. bbl.	Type of refinery
Mid-States Ref. Co., Falls City	3,000	.....	S
OHIO			
Erie Ref. Co., Warren	2,200	.....	S
OKLAHOMA			
Associated Refineries, Inc., Duncan[1]	.....	17,000	C
Shale Oil Co., Lawton	80	.....	S
Total	80	17,000	
SOUTH DAKOTA			
Sturgis Ref. Co., Sturgis	100	.....	S
TEXAS			
Abercrombie, J. S., and Harrison Oil Co., Sweeney	18,000	4,700	C
American Republics Corp., Houston	7,500	.....	S
Danciger Oil & Ref. Co., Longview	7,500	4,000	C
Humble Oil & Ref. Co., Ingleside	31,500	.....	S
Minerva Ref. Co., Corsicana	1,000	.....	S
Scurlock Oil Co., Post	750	.....	S
Western Ref. Co., Baldridge (Fort Stockton)	1,000	.....	S
Total	67,250	8,700	
WYOMING			
Douglas Refinery, Douglas	80	.....	S
Silver Tip Refinery, Yoder	100	.....	S
Total	180	.....	

Status of Government-Owned Aviation-Gasoline Facilities

Wartime operator and plant location—	Type of plant and location in respect to basic refinery	Major processing facilities, item	Capacity, bbl. per day	Status as of March 1, 1947
J. S. Abercrombie and Magnolia Pet. Co., Sweeney, Tex.	Complete refinery. Isolated.	F.C.C.	13,000	Negotiations under way for purchase. Plant shut down.
		Gas concentration	.....	
		HF alkylation	*4,000	
		C_4 isomerization	*1,500	
		Crude distillation	22,000	
		Thermal reforming	7,000	
Anderson-Prichard Refining Co., Cyril, Okla.	Gas concentration†	Gas concentration	*320	Sold to Anderson-Prichard
Ashland Oil & Refining Co., Catlettsburg, Ky.	Aviation gasoline. Adjacent to operator's refinery.	T.C.C.	10,000	Operated by Ashland on an experimental 1-year lease in attempt to convert unit to commercial production.
		Gas concentration	.....	
		HF alkylation	*3,000	
		C_4 isomerization	*250	
Associated Refiners, Inc., Beckett (Duncan), Okla.	Aviation gasoline. Isolated.	F.C.C.	10,000	Plant shut down. No serious negotiations under way.
		Gas concentration	.....	
		HF alkylation	*2,200	
		C_4 isomerization	*250	
Bay Pet. Corp, Denver, Colo.	Gas concentration†	Gas concentration	*130	Sold to Bay Petroleum Corp.
Continental Oil Co., Ponca City, Okla.	Aviation gasoline. Adjacent to operator's refinery.	T.C.C.	20,000	Sale negotiations under way.
		Gas concentration	.....	
		HF alkylation	*3,000	
		C_4 isomerization	*1,500	
		S.R. stabilizer	.....	
Cooperative Refining Co., Coffeyville, Kans.	Aviation gasoline. Adjacent to operator's refinery.	F.C.C.	3,800	Operator's bid of $1,120,000 rejected. Negotiations still in progress. Currently, operator is leasing parts of unit and has converted isomerization plant to catalytic polymerization operations.
		Gas concentration	.....	
		HF alkylation	*1,000	
		C_4 isomerization	*400	
Crown Central Pet. Corp., Pasadena (Houston), Tex.	Aviation gasoline. Adjacent to operator's refinery.	T.C.C.	10,000	Operator using part of plant on lease shows interest in purchasing entire plant.
		Gas concentration	.....	
		HF alkylation	*3,500	
		C_4 isomerization	*1,300	
Eastern States Pet. Corp., Houston, Tex.	Aviation gasoline. Adjacent to operator's refinery.	F.C.C.	5,000	Operator using portions on lease and shows interest in negotiations to purchase entire plant.
		Gas concentration	.....	
		HF alkylation	*1,600	
		C_4 isomerization	*600	
Frontier Refining Co., Cheyenne, Wyo.	Aviation gasoline. Adjacent to operator's refinery.	F.C.C.	2,700	Operator using parts of plant on lease and negotiating to purchase entire plant.
		Gas concentration	.....	
		HF alkylation	*1,100	
		C_4 isomerization	*450	
Great Southern Corp., Corpus Christi, Tex.	Miscellaneous. Adjacent to operator's plant.	HF alkylation	*1,500	Sold to Rubber Reserve Co. for butylene production.
		Thermal reforming	2,000	
		Dehydrogenation	*700	
		Feed preparation	5,000	
Chicago Corp., Agua Dulce, Tex.	Gas concentration†	Absorption	.....	Sold.
Chicago Corp., Bishop, Tex.	Gas concentration†	Absorption	.....	Sold.
Gulf Plains Corp., Driscoll, Tex.	Gas concentration†	Absorption	.....	Sold.
Lockhart Oil Co., Banguette, Tex.	Gas concentration†	Absorption	.....	Sold.

STATUS OF GOVERNMENT-OWNED AVIATION GASOLINE FACILITIES (Continued)

Wartime operator and plant location—	Type of plant and location in respect to basic refinery	Major processing facilities, item	Capacity, bbl. per day	Status as of March 1, 1947
Humble O. & R. Co., Baytown, Tex.	Hydrogenation†	Hydrogenation	13,000	Dismantled and equipment sold. Humble largest purchaser of salvaged items.
Mohawk Pet. Corp., Bakersfield, Calif.	Miscellaneous. Adjacent to operator's refinery.	Gas concentration	.....	Leased for 5 years to Oronite Chemical Co., Standard of Calif. subsidiary, for experimental production of chemicals.
		HF alkylation	*1,000	
		C_4 isomerization	*450	
		Thermal reforming	2,200	
Pan American Pet. & Transport Co., Texas City, Tex.	Aviation gasoline component.†	C_4 isomerization	*2,400	Operator leasing small part of plant and shows interest in purchasing entire property.
The Pennzoil Co., Oil City, Pa.	Aviation gasoline component.‡	Gas concentration	.....	Entire plant sold to Koppers Co. for manufacture of chemicals.
		HF alkylation	*1,500	
Premier Ref. Co., Cotton Valley, La.	Miscellaneous. Adjacent to operator's refinery.	Gas concentration	.....	In operation producing butylenes for rubber program.
		HF alkylation	*2,200	
		Dehydrogenation	*750	
The Pure Oil Co., Smiths Bluff (Nederland), Tex.	Alkylation.‡	H_2SO_4 alkylation	*1,330	Plant shut down. Pure negotiating to purchase.
Republic Oil Ref. Co., Texas City, Tex.	Aviation gasoline. Adjacent to operator's refinery.	F.C.C.	12,000	Operator using part of plant on lease and shows interest in purchasing all of property.
		Gas concentration	.....	
		HF alkylation	*1,800	
		Thermal cracking	5,000	
Root Pet. Co., El Dorado, Ark.	Aviation gasoline. Inside operator's refinery.	F.C.C.	4,800	Root's offer to purchase entire property being considered. Plant operated on lease meanwhile.
		Gas concentration	.....	
		HF alkylation	*1,300	
		C_4 isomerization	*250	
		Girbotol treating	.....	
American Liberty Oil Co. (was Southpart Pet. Co.), Texas City	Aviation gasoline. Adjacent to operator's refinery.	H.C.C.	13,000	Plant shut down; operator negotiating purchase.
		Gas concentration	.....	
		HF alkylation	*1,600	
Standard Oil Co. of California, Richmond, Calif.	Aviation gasoline. Adjacent to refinery on operator's land.	T.C.C.	14,000	Leased to operator who is actively negotiating to purchase.
		Gas concentration	.....	
		HF alkylation	*3,200	
Standard Oil Co. of New Jersey, Baton Rouge, La.	Hydrogenation.†	C_4 isomerization	*1,400	
		Hydrogenation	11,000	Dismantling and sale of salvaged equipment approved.
Utah Oil Refining Co., Salt Lake City, Utah	Aviation gasoline. Adjacent to operator's refinery.	F.C.C.	8,500	Purchased by operator.
		Gas concentration	.....	
		H_2SO_4 alkylation	*3,000	
		C_4 isomerization	*1,000	
		Naphtha isomerization	*1,500	
		Naphtha fractionator	5,000	
		Hydrogen generator	.....	
Wilshire Oil Co., Inc., Norwalk, Calif.	Aviation gasoline. Adjacent to operator's refinery.	F.C.C.	4,000	Plant shut down. WAA considering purchase bids.
		Gas concentration	.....	
		HF alkylation	*1,750	
		C_4 isomerization	*1,000	
ESCROW CONTRACT PLANTS				
Champlin Ref. Co., Enid, Okla.	Aviation gasoline component.‡	HF alkylation	*2,300	
		C_4 isomerization	*1,350	
		Gas concentration	.....	Purchased by operator.
Cities Service Oil Co., E. Chicago, Ind.	Aviation gasoline component.†	H_2SO_4 alkylation	*2,600	
		C_4 isomerization	*1,000	
		Gas concentration	.....	Sold.
Continental Oil Co., Wichita Falls, Tex.	Isopentane.	.....	.....	Sold.
Socony-Vacuum Oil Co., Inc., E. St. Louis, Ill.	B-B extraction.	.....	.....	Sold.

*Production. †In operator's refinery. ‡Adjacent operator's refinery. §From report of Surplus Property Administration with revisions to March 1, 1947, included.

New Engineering Fundamental Series Starts This Week

WITH the completion of the interrupted series of articles by Dr. E. A. Stephenson, head of petroleum engineering school, University of Kansas, which have been appearing as installments of the Journal's popular Engineering Fundamentals page, another author takes over the feature for several weeks. The purpose of the articles will be to show how acid can be used to lengthen the flowing life of wells, increase recovery, and the benefits of acidizing before squeezing operations commence. The discussions are based on practical experience gained over a period of 10 years.

E. N. JONES

The author, Edward N. Jones, is a consulting engineer of Pettus, Tex. He was educated at Texas A. & M., and University of Texas. His practical experience ranges from roustabouting and roughnecking, to pipe lining, rig building, production, and superintendent for a drilling contracting concern. He started his consulting engineering practice in 1945. He is a registered petroleum engineer, member of A.I.M.E., and chairman of the engineers committee on West Tuleta, Bee County, Texas, cycling operations.

The series by Jones starts in this week's issue, page 295.

BOOKS

JOHN WILKES BOOTH—OILMAN. By Ernest C. Miller. Published by The Exposition Press, New York. 85 pp. $2.50.

In this brief story the author has covered a phase of the assassin's life about which little was known, and that little generally inaccurate. The acting part of Booth's career is not ignored, but it is chiefly with Booth the oil man that the author has concerned himself. He has gone through considerable research to gather and collate his facts, the result being a readable account of Booth's adventure in the oil business. The volume, which throws new light on why Booth retired unwillingly from the stage, contains considerable references to aid the reader, and the photographs, published for the first time, lend pictorial interest to the text.

LEARNING TO WELD. Published by Lincoln Electric Co., Cleveland. 32 pp. 25 cents.

The purpose of this booklet is to explain the art of arc welding, for the repair of broken parts, building of equipment, and the hard surfacing of worn parts. It is intended to cover just the main points, briefly to provide a simple basic training with which to start arc welding.

PROGRESS IN METALS

by W. L. Nelson
Consulting Engineer

Chromium-Aluminum Steel Resists Oxidation

BECAUSE gasoline imports to Norway were cut off during the war, its use for private cars and buses was forbidden. Thus, gas producers using wood as fuel were installed. One of the most popular producers was based on the Imbert system, as applied by General Motors International, of Oslo. Combustion takes place on a hearth, the air entering through several small inlets into the main center, where descending wood is converted to carbon monoxide gas.

Temperatures as high as 2,375° F. (1,300° C.) were registered in the middle and the hearth was sometimes twisted and deformed. However, practically no scale was formed when the metal contained over 25 per cent chromium.

Essential requirements for hearth materials were: They must withstand a temperature of 2,000°-2,300° F. (1,100° to 1,200° C.) in an atmosphere of carbon monoxide gas in a bed of incandescent carbon; they must have ability to be welded to ordinary sheet iron without heat treatment; and must have fair machinability. At first, an alloy of 25 per cent chromium and 20 per cent nickel was used successfully, but soon had to be abandoned because of a shortage of nickel.

Tests were conducted to see whether a straight ferritic 25 per cent chromium steel could be used. It was concluded that 2,100° F. (1,150° C.) is the limit to which 25 per cent chromium steel can be heated in carbon monoxide gas. It was found that carbon up to 2.8 per cent lowers the melting point of the 25-30 per cent chromium steels.

High carbon also adversely affects the welding operation and makes the joint brittle. The same effects result from high silicon additions, though the alloy is more fluid when molten. After preliminary trials production was started and continued with encouraging results for 4 years, some cars covering 40,000 miles without having to change the hearth.

It was evident that carbon should be kept as low as possible, around 0.30 per cent, with silicon as low as possible, the nickel content should be about 2 per cent, and the nitrogen 0.20 per cent. This gives, with heat treatment, a tensile strength of 85,000 psi., with an elongation of 2 per cent.

The welding to the sheet iron without preliminary heating is done with very soft plain iron electrodes, having 1.50 per cent manganese. Low current density and plus polarity 3.25 mm. rod is used. When ferrochromium stocks ran short it was wondered whether aluminum could be used as a substitute. The greatest difficulty is that aluminum bestows brittleness upon the steel. With 6 per cent chromium and 6 per cent aluminum, the alloy supposedly can withstand 2,200° F. (1,200° C.)

The superiority of chromium steel over the new alloy is quite evident, but the chromium-aluminum alloy is cheaper. Heat resistivity of the new alloy is 27 times that of cast iron but a third to a fifth that of chromium steel at 1,650° F. (900° C.).

Abstract: J. Sissener (Heat Resisting Alloys), Foundry Trade Journal, Vol. 78, March 28, 1946, p. 341, taken from July 1946 issue of Materials and Methods.

Metals For Refinery Corrosion

THE corrosive attacks on the materials used in cracking and refining processes are explained. The principal corrosion problems are those caused by (1) acids (hydrochloric, sulfuric, hydrofluoric, phosphoric, etc.); (2) bases (sodium and potassium hydroxides, ammonium hydroxide, etc.); and (3) salts (aluminum chloride, boron chloride, etc.). A galvanic series of 43 metals is given in the order from the corroded end (least noble, anodic) formed by magnesium, to the protected end (most noble, cathodic) formed by 18-8-3 stainless-steel type 316 (passive).

Refinery corrosion is discussed in two groups, the dividing line of which is formed by the temperature level at which water is no longer present, assumed at 500° F. Above this temperature, "dry" corrosion is considered to take place due to the action of sulfur and also some organic acids; below this temperature, "wet" or electrolytic corrosion is assumed to take place.

A general survey of refinery corrosion is as follows: At temperatures above 500° F., chromium is the most useful metallic element to resist action of sulfur, the necessary concentration in the metal depends on the sulfur content and the nature of the sulfur compounds; 18 chromium 8 nickel, 11-14 per cent chromium steels, and 4 to 6 per cent chromium steels are widely used under these conditions.

Where naphthenic acids are a source of corrosion above 500° F., the following alloys are employed: Inconel (about 80 nickel, 13 per cent chromium), and type 316 (about 18 chromium, 14 nickel, 2 to 3 per cent molybdenum). At temperatures below 500° F., corrosion is considered to be electrolytic in character, assuming that liquid water is present to form an electrolyte; it takes place mostly in the condensing and isomerization equipment, alkylation units, caustic regenerators, in the hydrogenation process.

Condenser shells are of Monel-clad steel, or tubes of 70-30 copper-nickel are used that offer greater resistance to impingement attack than admiralty tubing. For isomerization equipment, Hastelloy B, an alloy of approximately 60 nickel, 32 per cent molybdenum is one of the most resistant to an hydrochloric atmosphere. Monel seems to be the most useful material in alkylation, using hydrofluoric acid as catalyst; it is used as liners for vessels, valves, rings, and packing. The same material is used also to line caustic regenerators.

Ni-resist cast iron (nickel or copper cast iron) of austenitic structure is useful for pumps and valve parts in handling caustic; 18 : 8 stainless steel is highly resistant to hydrogen attack although it suffers some temporary loss in mechanical properties due to mechanical presence of hydrogen in the metal; the hydrogen can be removed by heating, and its properties restored.

For other steels, presence of carbide forming elements (chromium, tungsten, or molybdenum) are required to prevent decarburization. In general, the more complex the carbide the more resistant is the metal to the carburization under hydrogenation conditions. Unless 12 per cent or more of chromium is present in the steel, sulfur attack must be expected.

Abstract: B. B. Morton, "Corrosion Re- A.S.M.E., Vol. 68, April 1946, pp. 229-235.

Steel for Heaters For Corrosive Crude

IN the heating of corrosive crude oils in the field Black, Sivalls & Bryson, Inc., Kansas City, Mo., has resorted to the use of nickel-chromium cast-iron heating coils. The coils range in pipe diameter from 2 to 2½ in. and are used in the indirect heater line of this company. Such an iron exhibits superior physical properties and uniformity as well as some corrosion resistance.

Metallurgical Terms

Phosphorous Banding

Phosphorous banding is a visible band occurring in metals and being caused by localized phosphorus. These bands are sometimes referred to as Ghost Bands.

MODERN Rotary DRILLING

Erection and Dismantling of Portable Drilling Masts

IN discussing portable drilling masts in the preceding installment, portability, strength and rigidity, speed of erection and dismantling, and safety were named as prime requirements for this type of equipment. With portability and strength and rigidity already considered the discussion is continued here.

Erection and Dismantling

From the point of view of manner of erecting and dismantling, all portable drilling masts may be divided into two groups, telescoping and sectional masts.

Telescoping masts.—Transported on a truck or a trailer, in a hori-

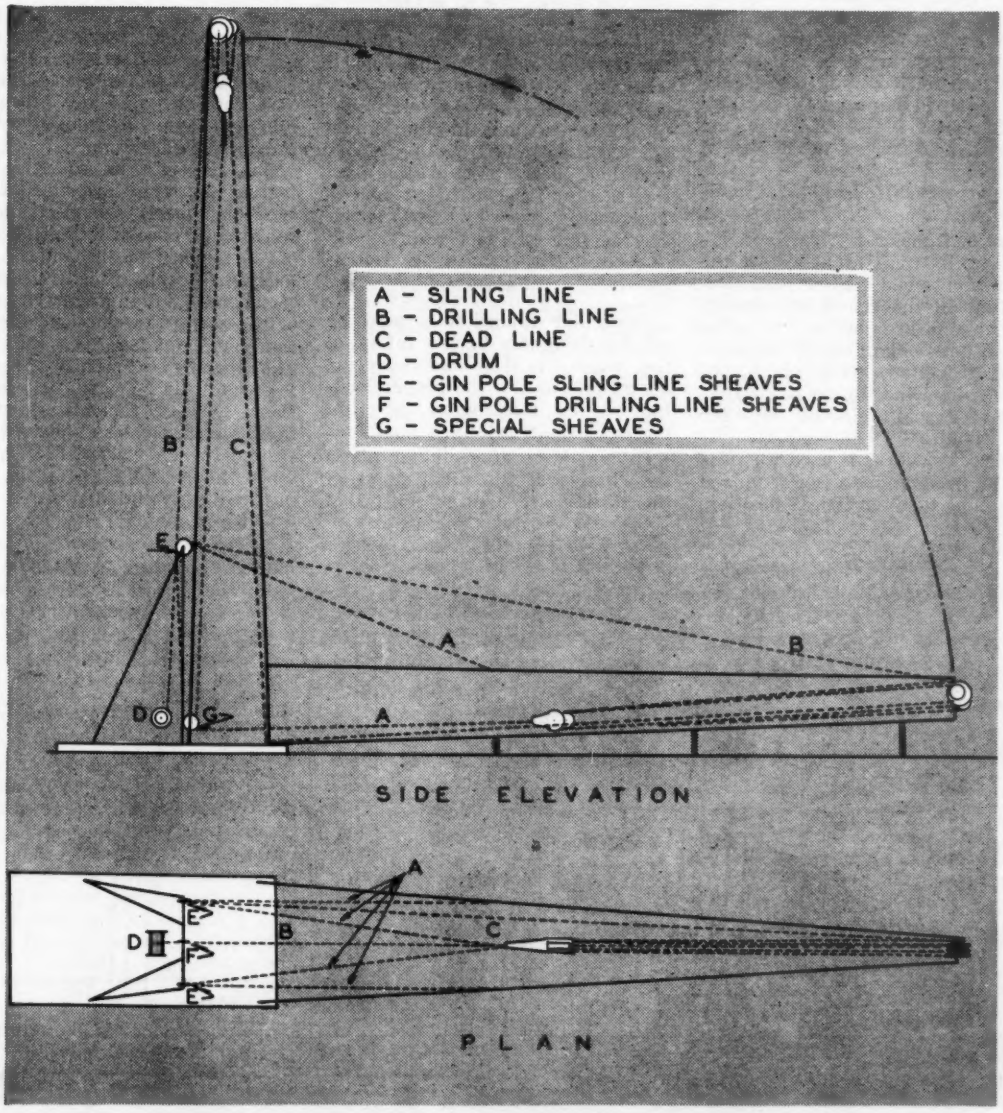

Fig. 11—Schematic outline of arrangement of the drilling line and sling lines for raising of a sectional drilling mast

No. 12 in a series by Joseph Zaba, petroleum engineer, Houston

Modern Rotary Drilling (continued)

zontal position, masts are erected in two stages. The telescoped part first is raised; then the mast is extended to its full height.

Raising of the telescoped mast from the horizontal to the vertical position is accomplished in one of several possible ways. Hydraulic systems of different types are used extensively. In one arrangement the telescoped mast is raised by a screw mechanism. This device consists of large-diameter screws, which are operated by drive nuts, internally lubricated and mounted on ball bearings. Truck engine furnishes the power. Or, the mast may be raised by means of the traveling block.

Extending the mast to its full height, once it is raised to the vertical position, is accomplished either by a line from a power-operated winch, or by the traveling block.

Sectional masts.—The mast is assembled horizontally on the ground, on wood sills or mats. Depending on the construction used, the sections are jointed by splice plates and bolts, or by flanges, bolted together with bolts and dowel pins, or by male-and-female-type joints, locked together with clamps.

The draw works is used for raising the mast in one piece from the horizontal to the vertical position. Methods of raising differ primarily in the manner of arrangement of the gin pole. Otherwise the procedures for different types of mast are quite similar. Sketch in Fig. 11 shows schematic arrangement of drilling line and the sling lines used in raising operations. The sketch does not represent any particular make of a mast but is rather a generalized outline of the method.

Sling line A, placed in the hook or a special adapter attached to the traveling block, is threaded through special sheaves G and gin-pole sheaves E, and is attached to the derrick legs. Drilling line B is strung from the drum D over the gin-pole sheave F and over the offset sheave in the crown block. Crown and traveling blocks are then strung for drilling and the drilling line is dead ended. The mast is raised by slowly spooling the line on the drum.

Safety

Particular attention is paid by all the designers to the safety of the masts, raising and lowering operations, and to the proper locking of the telescoping types of masts in their extended position.

In one type of sectional masts the change of the pivot point of the raising arc assures control of the lines during the raising and lowering operations. The mast is raised from horizontal position with front-leg pins acting as the center of the raising arc (Fig. 12-A). As the rear pin seats, the pivot shifts to the rear pins (Fig. 12-B). The center of gravity does not pass over the supporting bearing, which eliminates the slack line. Proper arrangement of gin pole and selection of the point of attachment of sling lines in other types of sectional masts, also have as their purpose the safety of raising and lowering operations.

Hydraulic systems, used for raising telescoping masts, are equipped with special safety devices. For instance, in case of one system, flow-check valves are provided, governing the rate of flow. Thus the lowering of the valve would proceed at a safe speed if any of the oil lines of the hydraulic system break. The screw mechanism, previously referred to, which is used for raising and lowering of one type of a mast, is irreversible except under power. Extension parts of telescoping masts usually have locking devices, spaced at 5-ft. intervals, so that in event of failure of the raising mechanism, the section could not fall more than 5 ft. The locking mechanisms usually are controlled from the derrick floor. One of the manufacturers furnishes an electrical alarm signal system, which warns the operator when the derrick is ready for locking in the extended position.

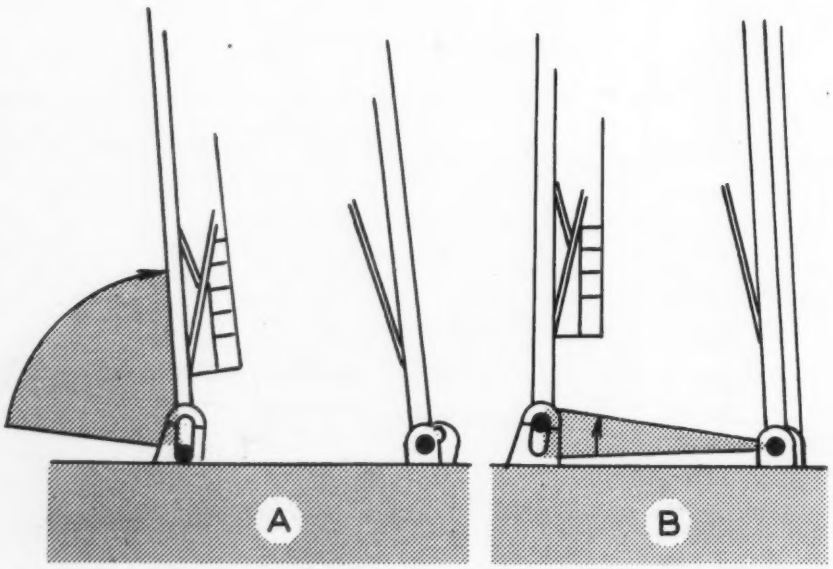

Fig. 12—Change of the pivot point in raising of a sectional mast

ENGINEERING *fundamentals*

Purpose of Acidizing Sand Formations

THE purpose of acidizing sand formations is to obtain from the producing horizons the ultimate maximum recovery with the least expenditure. Taking into consideration the permeability, thickness of sand, and bottom-hole pressure, oil or gas wells which are producing to their theoretical ultimate do not need acidizing. However, they do need acidizing if they have declined in production to such an extent that a greater drainage area is required to produce the needed quantity of fluids or gas. All wells, therefore, are not subjects for acid treatment. Each well is considered an individual problem in any field, regardless of its status. The true purpose of acidizing, then, is to increase the productivity of a well.

Before acidizing, investigation should be made as to the past history of the well. Core analyses and electric logs should be studied and correlated. The completion method should be taken into consideration. This is very easily done because of the unlimited amount of information that can be obtained by modern facilities available in the field, laboratory, and company records. These facts can be evaluated by competent engineers.

In many instances cores taken from sand bodies showing a very normal permeability and good saturation of oil have failed to produce when tested by drill-stem methods. These sands have been condemned as unproductive or without enough bottom-hole pressure to release the oil in the formation. Operators spend huge sums of money in drilling wildcat wells yet are hesitant to try out proved methods in completing new wells, or cleaning a formation of muds and water that has shown good saturation yet tested dry. The cleaning of these wells would result in the discovery of more reservoirs, which would produce more oil or gas per dollar invested.

It is a well-known fact that the greater the drainage area at the well bore the quicker the formation will give up the fluids being produced and the higher the percentage of recovery will be over the life of the well.

Many operators underream the formation to increase the drainage area or to remove the mud sheath formed at the face of the sand; however, they do not penetrate into the sand body with the underreamer any great distance. Mud is used as a circulating medium and what mud is removed is replaced by the muds circulated. Here is where the real damage is done. Mud and mud filtrate seal the void spaces in the sand body at the bore hole where the reservoir is tapped.

A formation, considered as a storage tank, cannot feed the proper amount of oil to the pipeline outlet if the connections are partially stopped. This happens in many cases where the annular spaces are cemented over, or bridged, by the filtration of muds or fresh water. It finally becomes so bad that formation fluids and gases are partially or completely prevented from entering the well bore. The extent to which a formation can be underreamed depends entirely on the diameter to which the tool blades of the underreamer can be extended. Some operators set pipe through the sand body and perforate, thereby eliminating the use of the underreamer. However, by the use of acid (provided there are parts of the sand body that can be dissolved) the drainage area can be extended an unlimited distance into the sand body. (Fig. 1). This area, of course, depends on the physical properties of the sand formation and the amount of acid used. The exact amount of acid cannot be 100 per cent estimated as to the area or drainage area it will create. This is because sands are not homogeneous in their structure. Vertical and horizontal permeability are seldom the same, therefore, they cannot be considered as perfectly uniform sand bodies.

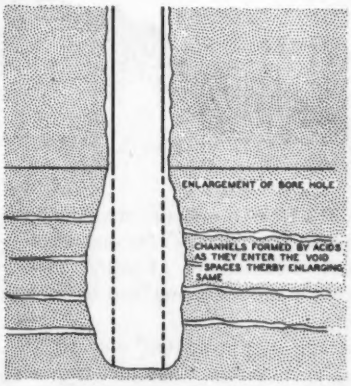

Fig. 1—Illustration showing effective drainage area caused by use of acids as the acids channel back into the formations enlarging the void spaces by destroying the cementation between the sand grains, and also enlarging the bore hole in proportion to the amount of acid used

A fairly accurate estimate of the amount of acid needed to dissolve that portion of the cementation which is capable of being dissolved can be made by crushing a part of the core, drying, and weighing. The crushed portion is then immersed in 15 per cent hydrochloric or, preferable, mud acid, and vigorously shaken or stirred for a few minutes. The portion remaining of the sample is then washed, dried, and weighed. The weight lost can be figured as the percentage or the quantity of formation dissolved. If this experiment is done in a glass container, one can observe the reaction of the acid on the sample. These tests are simple and can be performed in the field. For a laboratory test, more technical equipment is used. In the above test the acid should be heated to 150° to 250° F. The temperature should be comparable to the bottom-hole temperature of the well in which the acid is to be used. An increase in temperature hastens the reaction rate of acid with those agents which can be dissolved.

Series Prepared by Edward N. Jones, consulting engineer, Pettus, Tex.

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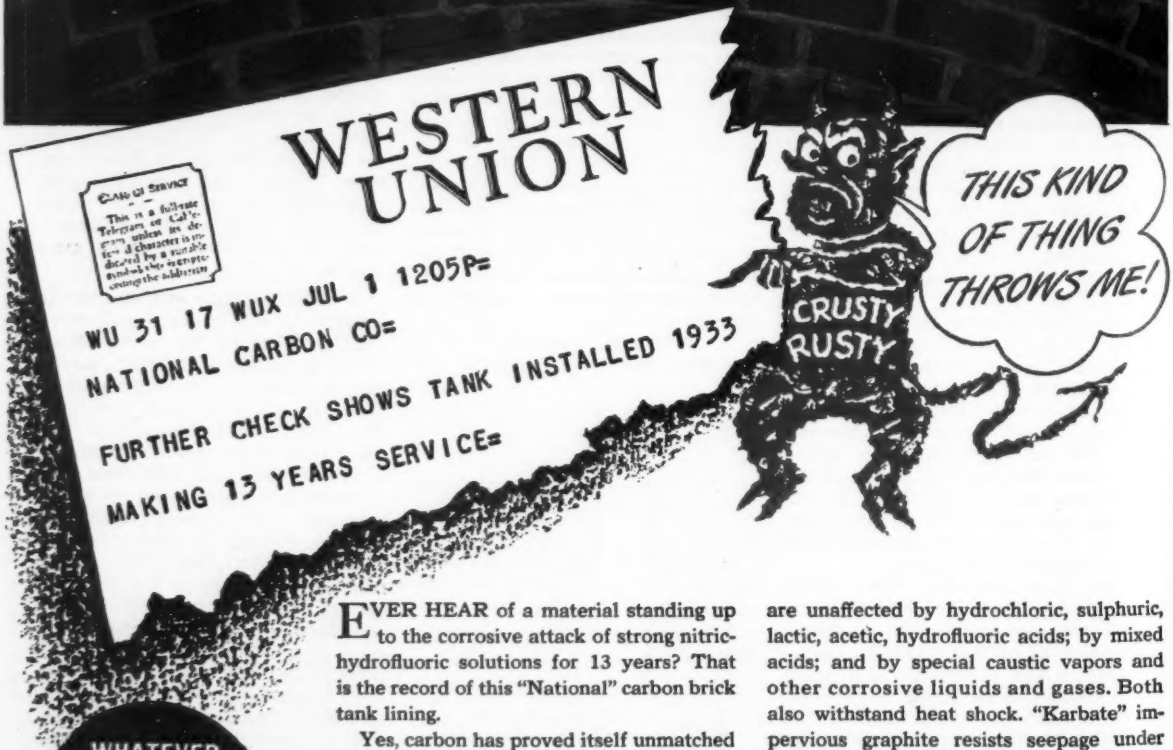
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The Refiner's Notebook

A WEEKLY FEATURE OF THE OIL AND GAS JOURNAL

Estimating Centrifugal-Pump Capacity

THE chart shown on this page permits estimation of the capacity of a single-stage centrifugal pump by knowing only the diameter of the pump suction and the head produced at closed suction. It thus permits determination of the approximate capacity of pumps without name plates or on which design data are not available.

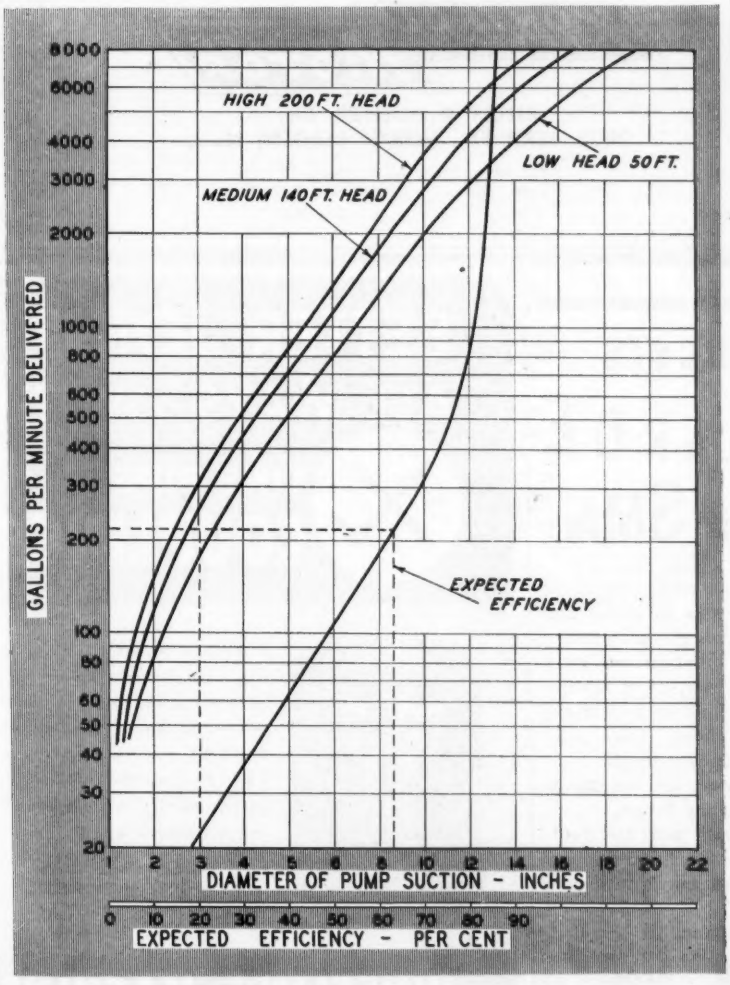


Fig. 1

The chart is used by reading upward from the diameter of suction shown on the bottom, to the proper "head line" and then reading horizontally to the gallons-per-minute scale. The approximate relationships between suction diameter (D) and capacity in gallons per minute (Q) are:

Low head—50 ft. H_2O

$$D = \sqrt{\frac{Q}{20}}$$

Medium head—140 ft. H_2O

$$D = \sqrt{\frac{Q}{30}}$$

High head—200 ft. H_2O

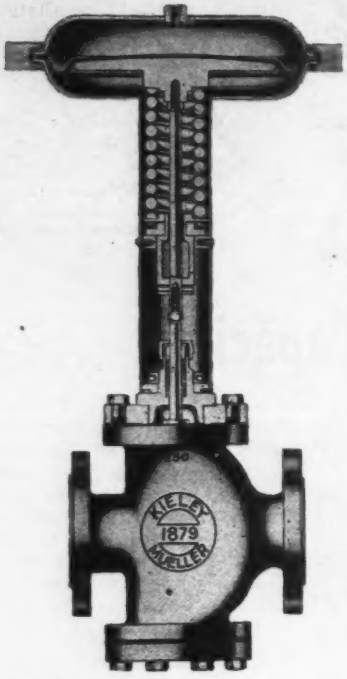
$$D = \sqrt{\frac{Q}{36}}$$

In addition an efficiency curve is shown by which the approximate efficiency at the proper capacity for the pump can be estimated. It is not necessary to use or do anything about the efficiency curve.

Example.—A single-stage pump with a 3-in. suction connection exhibits a head of 100 ft. when operating on a closed discharge. Reading upward from 3 in. to a point between the 50 and 140-ft. head lines as shown by the dotted line, a capacity of about 220 g.p.m. is indicated on the left side. An efficiency of about 63 per cent is indicated.

This chart and method were published first by Bill Maddock in the October 1942 issue of Power Plant Engineering and was revised and republished in February 1946.

No. 136 in a series by W. L. Nelson, professor of petroleum refinery engineering, University of Tulsa



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NATURAL GAS

Panhandle Asks Permit For Third Expansion

WASHINGTON. — Panhandle Eastern Pipe Line Co. has filed an application with the Federal Power commission requesting authorization to construct and operate additional pipe-line facilities in Texas, Kansas, Missouri, Illinois, Indiana, and Michigan. The facilities are to be added to the Group A and B facilities recently authorized by the FPC and are estimated to cost approximately $23,464,000.

Designed to raise the peak-day capacity of the Panhandle system approximately from 473,000,000 to 580,000,000 cu. ft. per day, the facilities proposed include construction of about 356 miles of 26-in. pipe as a third loop line and installation of an aggregate of 37,600 hp. in existing compressor stations.

The Group A facilities authorized by the commission in June 1946 have now been completed and are in operation, the application stated, and construction of the Group B facilities authorized in November 1946 will be commenced as soon as the necessary pipe and appurtenant equipment is available. In connection with the latter facilities, Panhandle has submitted a petition to the FPC for permission to make substitutions and changes in its project as originally authorized. These proposed changes include construction of a new 2,400-hp. compressor station in Haskell County, Kansas, as a substitute for the 2,400-hp. authorized at Hugoton station, the installation of 7,200 hp. instead of 6,000 hp. at the Liberal station, and the laying of about 10.6 miles of 26-in. loop line as a parallel pipe line into the Liberal station from Texas instead of the authorized 34 miles of 18-in. loop line in Kansas between Hugoton and Liberal stations.

The Group A facilities increased the pipe-line capacity to approximately 393,000,000 cu. ft. per day, and the B facilities are designed to increase capacity to about 473,000,000 cu. ft. per day.

Hearing Set March 31 On T. G & T. Expansion

WASHINGTON.—The Federal Power Commission has set for hearing on March 31 an application filed by Tennessee Gas & Transmission Co. for authorization to construct facilities to increase the delivery capacity of its natural-gas transmission pipe line to 600,000,000 cu. ft. daily. The hearing will be in the FPC Hearing Room, Washington.

Facilities requested include about 552 miles of 26-in., about 69 miles of 24-in. and about 82 miles of 20-in. loop line extending along the company's main line, an aerial-suspension pipe line crossing the Mississippi River, approximately 83 miles of 20-in. line extending from a compressor station in Natchitoches Parish, Louisiana, to the Carthage gas field in Panola County, Texas, and various other lateral gas lines to connect the system to required additional supplies of natural gas, a new compressor station of 6,000 installed horsepower in Nueces County, Texas, and installation of compressor units totaling 75,400 hp. in existing stations. Total cost has been estimated at $53,000,000.

Flared Gas Reduction Of 60 Per Cent Reported

A reduction from 1941 to 1946 of more than 60 per cent in the amount of gas flared in Louisiana, despite a sharp increase in oil production during the same period, is reported by the state Conservation Department.

The department reported flared gas totaled more than 550,000,000 cu. ft. daily in Louisiana fields in 1941 and that it now is about 217,000,000 cu. ft. daily. Oil production increased from 265,000 bbl. daily to upwards of 400,000 bbl. daily during the 5 years. New markets and outlets have been found for gas previously flared, and the use of cycling plants also has helped cut gas wastage.

Second Gas-Technology Short Course Planned

A second annual short course in gas technology will be held at Texas College of Arts and Industries, Kingsville, May 27-30 under the sponsorship of the Southern Gas Association.

Procedure of the course will be similar to last year's conference, which attracted more than 200 gas-industry representatives from 10 states. Facilities of the college natural-gas laboratory as well as inspection trips to installations near Kingsville will again be available to the registrants.

Two sections of study have been announced by Dr. Frank J. Dotterweich, head of the college engineering department, who is again serving as chairman of the administrative committee. "Technical Problems in Transmission" is the subject of the first section, which will be headed by R. M. Hutchinson, research director of the Houston Natural Gas Corp. W. C. McGee, Jr. of the Tennessee Gas & Transmission Co., Houston, is vice chairman of the transmission section. The other will be "Technical Problems of Gas Utilization," arranged by George Elmer May, utilization engineer for New Orleans Public Service, Inc. C. A. McKinney of the United Gas Corp., Houston, is assisting May.

Instructors will be research experts, engineers, and college faculty members. An all-day inspection trip to the Rio Grande Valley is on the schedule. The tour will include visits to cycling and dehydration plants.

Natural Gasoline

Benton Field Cycling Plant To Be Completed This Year

A cycling plant with a capacity of 50,000,000 cu. ft. of gas daily and designed to recover 4,000 bbl. of liquid products daily is expected to be completed late this year in the Benton gas-distillate field in Bossier Parish, La.

In its annual report, Barnsdall Oil Co., operator and owner of a substantial interest in the unitized project which covers 9,440 acres and now contains 15 wells, pointed out that efficient recovery of the distillate reserve requires that the gas be cycled. All wells are shut in awaiting completion of the plant, the report said.

The Barnsdall report, noting that revenue from the sale of gas in the Gulf Coast area, was doubled last year, said a compression plant has been completed for the gathering of low-pressure gas in Placedo field, Victoria County, Texas, and that another plant in the area is yet to be completed. It is expected, the report added, that additional properties will receive pipe-line connections during 1947.

Reporting on its California operations, Barnsdall said construction now in progress at the pressure-maintenance plant in the Newhall-Potrero field, Los Angeles County, will increase present compressor-plant size from 3,100 to 5,500 hp.

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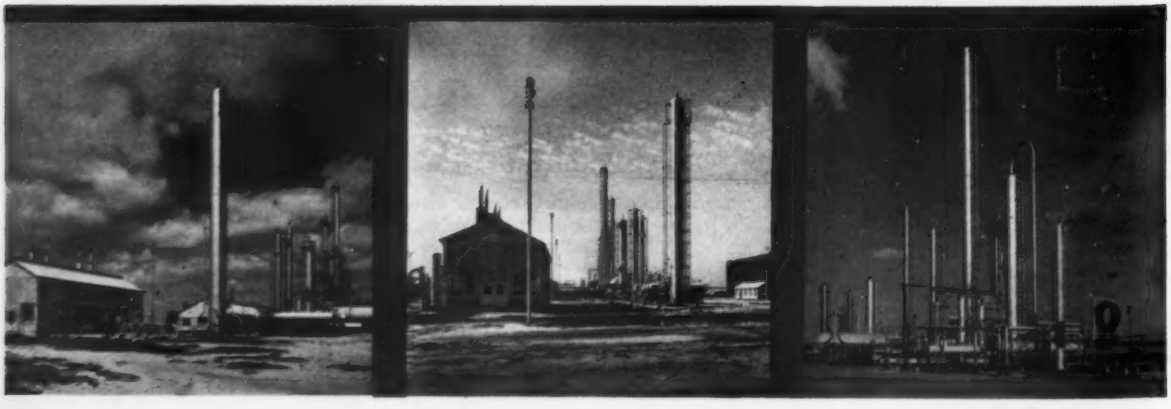

REFINING

Rural Market Discussion Added to W.P.R.A. Program

A talk on "The Rural Market for the Petroleum Industry" by Don Ross, representing the Agricultural Publishers Association, has been scheduled on the program for the thirty-fifth annual meeting of the Western Petroleum Refiners Association at the Plaza Hotel in San Antonio, Tex., March 24-26.

Ross will speak at the general session Wednesday, March 26. His talk on the agricultural market for the industry represents one of three phases to be discussed in the general sessions. Other speakers will discuss military requirements, research and scientific studies necessary to meet changing plans of the military, and the general supply-and-demand picture, both domestic and international.

Making final preparations for the program this week, the association announced members of a panel on catalytic cracking to be conducted at Tuesday morning technical session. They include Dr. J. W. Bertetti, Root Petroleum Co., El Dorado, Ark.; Hugh A. Neal, Phillips Petroleum Co.; Oscar Anderson, Globe Oil & Refining Co., Lemont, Ill.; H. D. Noll, Houdry Process Corp., New York; and J. B. Godwin, Magnolia Petroleum Co., Beaumont, Tex.

Association officials are anticipating registration at the meeting to exceed the record 550 who attended last spring's meeting in Fort Worth. The complete program was announced earlier this month *(The Oil and Gas Journal, March 8, page 106.)*

Sharples, Continental Form Chemical Company

A new company, Sharples-Continental Corp., owned equally by Continental Oil Co. and Sharples Chemicals, Inc., has been organized for the purpose of manufacturing monononylnaphthalene and dinonylnaphthalene, lubricating-oil additives.

The chemicals will be manufactured at Continental Oil Co.'s refinery site in Baltimore, Md. The refinery itself was shut down some time ago, and the tankage converted to terminal uses. Some of the available refining-processing equipment is being utilized for the new chemical manufacture, which is reported being undertaken in view of the shortage of fats.

Officers of the new company are Paul Kendall, of Sharples, president; Harold G. Osborn, vice president of Continental, vice president; John F. Towle, treasurer; and Howard I. Cramer, secretary.

German Tar-Fractionating Still Described in Report

WASHINGTON. — A continuous vacuum still, developed by the Germans for fractionating dehydrated high-temperature tar into anthracene, naphthalene, carbolic and Solvay wash oils, is described in a report by the Office of Technical Services, Department of Commerce. A two-stage adaptation of the vacuum still which was operated in Germany on a pilot-plant scale for distilling low-temperature carbonization tar is also discussed in the report which was prepared by representatives of the British Intelligence Objectives Subcommittee.

The high-temperature vacuum still is composed of 104 convection and 86 radiation tubes equipped with specially designed headers to facilitate tube cleaning. The fractionation equipment has one pitch column with an expansion valve to prevent volatilization of the tar and three oil columns.

The dehydrated tar flows through a heat exchanger to the tube still, entering the still at 90-lb. pressure and at a temperature of about 100° C. The convection space is divided by fire-retardant brick walls into six compartments, designed to level up the chimney pull across the still. Each section has two outside dampers and a pyrometer to ensure even distribution of temperature. There are no plugs in the headers of either the convection or radiation tubes to complicate cleaning. Instead, the tubes are expanded into cast steel flanges to which the headers are bolted.

The radiation bank has a heating area of 1,700 sq. ft. The normal two rows of tubes are set in the roof with a section of the tubes set at right angles down the front wall to increase the tube-heating surface without altering the furnace dimensions. The radiation tubes are encased in special fire-brick blocks, supported from the roof by silicon chromium hangers. Tar leaves the tube still at 320° C. and at a pressure of 45 lb.

The main walls of the still are constructed of four layers of fire bricks strengthened by silicon-chromium steel ties laid in the brick work. The still is heated by a four-burner coke-gas furnace in the cellar. Four indicators in the cellar measure gas pressure, gas quantity, chimney draft and carbon dioxide content of flue gases.

The fractionation plant is completely housed in a reinforced concrete brick panelled building. The hot tar enters the pitch column through a 245-ft. pipe line with an expansion valve at the point of entry.

Humble to Establish 12 Graduate Fellowships

HOUSTON.—Offers to establish 12 one-year fellowships in science and engineering have been made by Humble Oil & Refining Co. to five universities in the Southwest and South and to Massachusetts Institute of Technology.

Three fellowships, one in geology, one in chemical engineering, and one in chemistry, have been offered to the University of Texas; one in civil engineering and one in mechanical engineering were extended to Texas A. & M. College; one in physics and one in chemistry to the Rice Institute; one in petroleum engineering, and one in geology to both the University of

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Oklahoma and to Louisiana State University; and one in chemical engineering to M.I.T. Recipients will be students enrolled in master's or doctor's degree work.

A.C.S. Regional Meeting To Be Held June 23-25

The fifteenth Midwest regional meeting of the American Chemical Society is scheduled for Kansas City, Mo., June 23-25.

Secretary for the petroleum-group meeting is H. M. Steininger, Sugar Creek, Mo., Standard Oil Co. (Ind.), to whom all matters pertaining to the petroleum part of the meeting should be addressed. Steininger has issued a call for all papers to be offered at the meeting and asks to be advised of such papers as soon as possible.

A.C.S. regulations governing papers will apply to those presented at the meeting. One-thousand-word abstracts of papers should be submitted by April 1, Steininger said.

Shell California Group Given Safety Award

For carrying out 1,279,349 hours of work without a single disabling accident, employes in the Wilmington-Dominguez, Calif. refinery of Shell Oil Co., Inc., recently received the American Petroleum Institute accident-prevention certificate.

The safety record was set between July 14 and December 30, 1946. The last such award covering an entire Shell refinery on the Pacific Coast was made to workers in the Martinez plant in 1938.

New Computer to Aid Diesel-Fuel Research

Development of an electronic computer capable of solving mathematical formulas to determine the temperatures of exploding gases in engine cylinders and serving as an accessory to plot them on an oscillograph has been announced by mechanical engineers at the University of Wisconsin. The announcement said the new development holds hopes of aiding in the early development of new and better fuels for diesel engines.

Poly Unit Under Construction

A small catalytic polymerization unit of Universal Oil Products Co. design is now under construction at the 4,000-bbl. daily crude capacity refinery of Elk Refining Co. at Falling Rock, W. Va. The unit, to be completed about August 1, will handle gases from the refinery's present cracking units, producing approximately 90 bbl. per stream day of poly gasoline. Construction contract was awarded to Refinery Engineering Co., Chicago. The unit is similar to several others now in operation at various Pennsylvania refineries.

Tool Exhibit Scheduled

WASHINGTON.—A month-long exhibit and demonstration of outstanding German machine tools will be held at Frankford Arsenal, Philadelphia, March 31 through May 2, according to John C. Green, director, Office of Technical Services, Department of Commerce. Items to be displayed include various types of grinding, rolling, and milling machines, measuring and testing apparatus, and plastics processing equipment.

Maintenance Shop Planned

Gulf Oil Corp. is planning construction of a new maintenance shop at its Philadelphia refinery which will be used for periodic disassembly and inspection of refinery units. The shop, a modern 1½-story plant, will contain cranes up to 20-ton capacity and all types of metal-working machinery for routine and emergency repairs. It will warehouse replacement materials scheduled for as long as a year in advance as well as the 30 to 40 scaffolds used in continuous takedown and reassembly.

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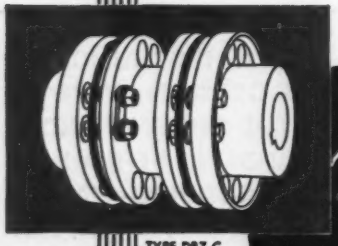

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PIPE LINES

Gulf Preparing to Loop 105 Miles of Texas Line

Gulf Refining Co., pipe-line division, is making plans to lay 105 miles of 8 and 10-in. loops on its crude-oil line from Midland to Lufkin, Tex.

Pipe for the first section in the project, 20 miles of 10-in. near the Weatherford station, is to be delivered in April. Completion is expected in about 30 days. Latex Corp., Houston, has been awarded the contract.

The complete looping program will increase the crude-carrying capacity of the line to about 120,000 bbl. daily. The system is now averaging about 106,000 bbl. daily, with 9,800 bbl. daily consigned to the Sweetwater refinery of the company. The system extends south to Port Arthur where Gulf operates a 167,200-bbl. daily capacity refinery.

In looping the line, the company will use 10 in. for the entire 105 miles except 12 miles of 8 in. the vicinity of Elkhart.

Pipe Laying Started for Socony's Venezuelan Line

Williams Brothers Corp. has started laying pipe for a crude-oil line from the greater Oficina and San Joaquin fields in Venezuela to a connection with the Cie. Consolidada (Sinclair) pipe line, through which deliveries are to be made at Puerto la Cruz.

The line is being laid for the Venezuelan subsidiary of Socony-Vacuum Oil Co., Inc.

Williams Brothers Corp. recently completed a 40-mile, 10-in. water line for Creole Petroleum Corp. in the Anaco area and 34 miles of 16-in. loops along the Mene Grande Oil Co.'s 16-in. Oficina-Puerto la Cruz trunk line.

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New York, Texas Offices Opened by Texas Eastern

E. Holley Poe, president of Texas Eastern Transmission Corp., has established headquarters of the new corporation at 70 Pine Street, New York City.

Texas operating headquarters have been opened by Charles I. Francis, vice president, at 1103 Esperson Building, Houston.

R. H. Hargrove, vice president of United Gas Pipe Line Co., has been loaned to serve as general manager of Texas Eastern and at present is dividing his time between the New York office and trips along the Big Inch and Little Big Inch lines.

The new corporation will start operation of the Inch systems in the unusual position of having a larger market demand at the outset than the lines can supply.

In negotiating for a 20-year supply of gas, contracts are being made on the basis of current values, eliminating the escalator schedule of prices commonly used.

Brown & Root, Inc., will handle construction engineering matters for Texas Eastern.

Humble Pipe Line to Extend West Texas System

Humble Pipe Line Co. is reported preparing to begin construction within the next few weeks on extensions of its West Texas crude-oil system.

Several sweet-crude pools in Andrews, Ector, and Winkler counties will be served by the new lines. Twenty-five miles of 6 in. is to be laid from the south end of Martin pool in Andrews County across the Andrews-Ector County line to Andector pool. The line will extend southwest to Wheeler pool of eastern Winkler and west with 17 miles of 8-in. to the Winkler station and tank farm. A 4-in. 4-mile lateral is to be laid north to Ellenburger production in the Keystone district.

Stanolind to Construct West Texas Crude Lines

Approximately 22 miles of 6-in. crude-oil pipe line will be built by

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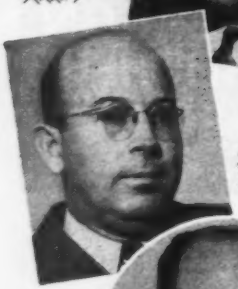
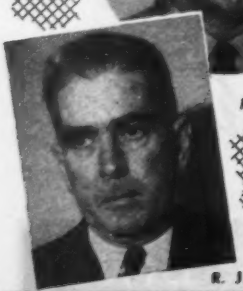

T. A. HESTER

N. K. McFARLAND


R. J. O'CONNELL

DALLAS, TEXAS

Stanolind Pipe Line Co. to tie three West Texas pools into the Stanolind system.

From the recently discovered Petersburg field in southeast Hale County, Stanolind is planning 7.2 miles of 6 in. which will extend south to the company's 16-in. trunk line. The Petersburg line is to connect with the trunk line in Section 29, Block C, in northeast Lubbock County. The Stanolind trunk extends from Sundown in Slaughter field in south Hockley County to Drumright, Okla.

Another line will consist of 11.7 miles of 6 in. from a point on the 16-in. trunk in north-central Lubbock County about 2 miles southwest of Monroe, extending northwest to Irish field in southwest Hale County. Another line will consist of 3.5 miles of 6 in. connecting Irish pool with Anton field in southeast Lamb County.

Pipe for Bolivia to Be Shipped via Argentina

To avoid transporting it over a mountainous route, 75 miles of 6-in. pipe for the 200-mile line to be built for Yacimientos Petroliferos Fiscales of Bolivia, will be sent to the project via Argentina.

First shipment of 25 miles of pipe, scheduled to leave the mills within the next few weeks, will be transferred at Buenos Aires from ships to rail cars, which will carry the load to a point 200 miles from the right-of-way. The pipe will be trucked the remaining distance.

The remainder of the pipe will be shipped to the site via Antofogasta, Chile. George Allen, superintendent for Williams Brothers Corp., which is constructing the line, recently returned to the United States on vacation.

Interstate Taking Bids

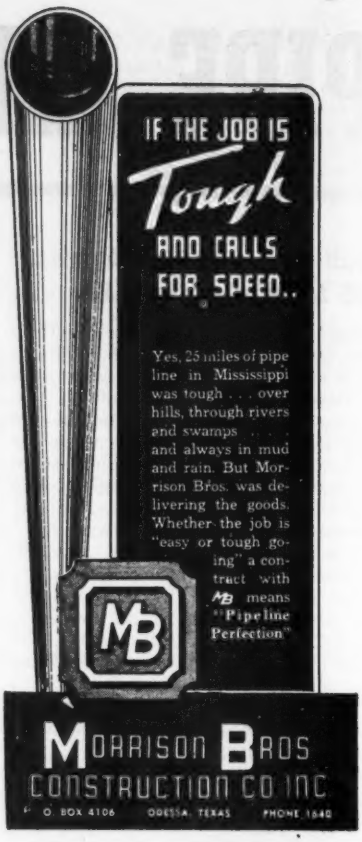
Interstate Oil Pipe Line Co. is now receiving bids on the construction of 18 miles of crude-oil pipe line in Adams County, Mississippi.

The proposed line will consist of 10 miles of 6-in. from the company's main-line pumping station at Cranfield to La Grange field, and 8 miles of 4-in. from La Grange to Carthage Point field, all in Adams County.

Stanolind Line Delayed

Construction of an 80-mile extension to Stanolind Pipe Line Co.'s main Drumright, Okla.-West Texas 16-in. line has been delayed by the recent postponement of pipe-line deliveries.

Contract already had been awarded R. H. Fulton & Co. and construction was scheduled to begin April 15. J. J. Boyd recently became a partner in R. H. Fulton & Co.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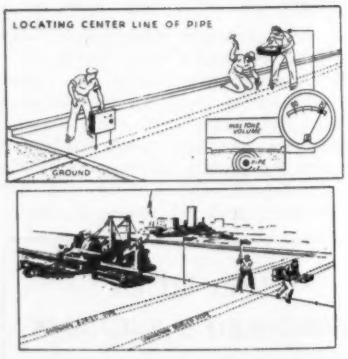

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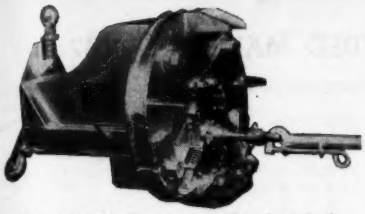

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1947
Our 25th Year

Corrosion Conference Will Open April 7

THREE sessions of particular interest to the petroleum industry are included in the program for the 1947 all-corrosion conference of the National Association of Corrosion Engineers in Chicago.

The conference will begin Monday, April 7, and continue through April 10. Headquarters of the meeting will be in the Palmer House.

An oil-industry symposium has been scheduled for Wednesday morning, a gas-industry symposium for Wednesday afternoon and a symposium on cathodic protection for Thursday morning. Running simultaneously with the cathodic-protection symposium will be a general-industry symposium during which Norman Hackerman, University of Texas, will speak on "The Use of Inhibitors in Corrosion Control."

Sections of the program of particular interest to the petroleum industry follow:

WEDNESDAY, APRIL 9

Oil-Industry Symposium, 9 a.m.—Chairman: J. M. Pearson, Sun Oil Co., Chester, Pa.; Cochairmen: W. F. Rogers, Gulf Oil Corp., Houston, and A. Wachter, Shell Development Co., Emeryville, Calif. "Arsenic as a Corrosion Inhibitor in Sulfuric Acid," A. Wachter, R. S. Treseder and M. K. Weber, Shell Development Co., Emeryville, Calif.; "Silicates for Corrosion Inhibition in the Oil Industry," William Stericker, Philadelphia Quartz Co., Philadelphia; "Cathodic Protection for Pipe Lines," Alan C. Nelson, Plantation Pipe Line Co., Atlanta, Ga.; "Effect of Carbide Structure on Corrosion Resistance of Steel," R. W. Manuel, Phillips Petroleum Co., Bartlesville, Okla.

Gas-Industry Symposium, 2 p.m.—Chairman: A. N. Horne, Texas-Empire Pipe Line Co., Tulsa; cochairmen: Guy Corfield, Southern California Gas Co.; Los Angeles, and F. J. McElhatton, Panhandle-Eastern Pipe Line Co., Kansas City. "Results Obtained With Pearson's Holiday Detector," A. H. Cramer and W. R. Fraser, Michigan Consolidated Gas Co., Detroit; "Alloying Steels for Corrosion Resistance to Gas-Condensate Fluids," K. Eilerts and Faye O. Greene, petroleum station, Bureau of Mines, Bartlesville, Okla.; "Statistical Analysis of Test Containers for Condensate Corrosion Studies," V. V. Kendall, National Tube Co., Pittsburgh; "Chimney-Liner Corrosion Resulting from Gas-Fired Furnaces," G. B. Johnson, Minneapolis Gas Light Co., Minneapolis.

THURSDAY, APRIL 10

Cathodic-Protection Symposium, 9 a.m.—Chairman: R. H. Crowe, Stanolind Pipe Line Co., Tulsa. Cochairmen: Scott Ewing, Carter Oil Co., Tulsa, and R. A. Brannon, Humble Pipe Line Co., Houston. "Aluminum Galvanic Anodes," Part I—Laboratory Tests, R. A. Hoxeng and R. H. Brown, Aluminum Co. of America, New Kensington, Pa.; Part II—Field Tests, Ellis Verink, R. A. Hoxeng, and R. H. Brown, Aluminum Co. of America, New Kensington, Pa.; "The Determination of Pipe Protection by the Continuous Polarity Method," William E. Huddleston, Huddleston Engineering Co., Bartlesville, Okla.; "Selection and Location of Anode Systems for Cathodic Protection," D. B. Good, Texas Pipe Line Co., Tulsa; "Electrical Measurements in Cathodic Protection," J. M. Pearson, Susquehannah Pipe Line Co., Philadelphia, Pa.

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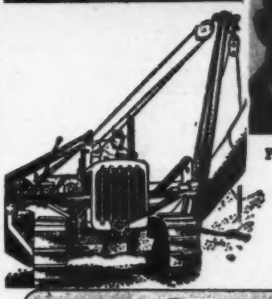

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STATISTICS and T

WEEKLY WELL COMPLETIONS . . . WEEK ENDED MARCH 15, 1947

	Total of all wells					Cum.		Wildcat completions and discoveries					Cumulative total, 1947				
	Comp.	Oil	Gas	Dry	Footage	1947	1946	Oil	Dist.	Gas	Dry	Total	Oil	Dist.	Gas	Dry	Total
New York	27	14	0	*13	43,229	291	322	0	0	0	0	0	0	0	0	0	0
Pennsylvania	62	32	4	†26	94,248	675	879	0	0	0	0	0	0	0	0	0	0
West Virginia	12	2	9	1	28,478	177	138	0	0	0	0	0	0	0	0	0	0
Ohio	16	1	8	7	58,440	240	218	0	0	0	2	2	0	0	1	10	11
Indiana	17	9	0	8	31,169	89	56	0	0	0	1	1	1	0	0	6	7
Kentucky	9	2	4	3	14,953	80	88	0	0	0	0	0	0	0	0	8	8
Illinois	41	23	0	18	110,156	395	391	1	0	0	4	5	15	0	0	59	74
Michigan	3	3	0	0	9,313	125	138	1	0	0	0	1	1	0	3	49	53
Kansas	29	8	9	12	90,669	533	433	0	0	1	5	6	8	0	6	62	76
Neb., Mo., Iowa	1	0	0	1	250	2	4	0	0	0	1	1	0	0	0	2	2
Oklahoma	73	45	4	24	217,554	839	508	0	0	1	12	13	21	0	2	153	176
Texas	165	108	10	47	810,298	1,642	1,544	7	4	2	24	37	55	11	14	260	340
North Central	37	23	0	14	115,716	505	532	3	0	0	7	10	25	0	4	94	123
West	39	36	0	3	179,876	413	311	0	0	0	1	1	5	0	1	34	40
Panhandle	8	2	6	0	23,005	92	78	0	0	0	0	0	1	0	0	0	1
Eastern	7	5	0	2	40,543	95	147	0	0	0	2	2	1	0	0	24	25
Gulf Coast	34	19	4	11	232,416	313	369	1	2	2	6	11	12	7	8	53	80
Southwest	40	23	0	17	218,742	224	107	3	2	0	8	13	11	4	1	55	71
Louisiana	20	13	1	6	125,945	227	262	1	0	0	3	4	10	6	0	29	45
Northern	10	7	1	2	29,698	106	130	0	0	0	1	1	0	0	0	16	16
Southern	10	6	0	4	96,247	121	132	1	0	0	2	3	10	6	0	13	29
Arkansas	4	4	0	0	21,909	42	37	0	0	0	0	0	0	0	0	6	6
Mississippi	6	4	1	1	53,257	71	50	0	0	0	0	0	0	0	1	19	20
Southeastern States	1	0	0	1	3,847	11	11	0	0	0	1	1	0	0	0	10	10
Montana	6	1	2	3	13,793	36	52	0	0	0	3	3	0	0	0	8	8
Wyoming	4	3	0	1	15,605	48	42	1	0	0	0	1	4	0	1	9	14
Colorado-Utah	4	2	0	2	26,562	31	23	0	0	0	1	1	1	0	0	7	8
New Mexico	8	4	3	1	26,722	100	82	0	0	0	0	0	2	0	1	9	12
California	40	34	0	6	153,180	416	372	2	0	0	2	4	4	0	0	57	61
Total United States	548	312	55	181	1,973,676	6,070	5,650	13	4	4	59	80	122	17	29	763	931
Total previous week	575	334	67	174	2,072,735	5,522	5,109	14	4	1	66	85	109	13	25	704	851
Total Mar. 16, 1946	541	304	48	189	1,823,384		*	10	3	2	64	79	92	5	25	621	743

Service wells included: *13, †23.

MARKET QUOTATIONS

GRAVITY SCHEDULES

Top prices include all gravities above grades designated, and low prices include all gravities below grades designated:

Gravity—	Signal Hill, Calif.	Okla-homa, Kansas	Gulf Coast Tex.*	West Tex.†
18-18.9	$1.17	....	....	....
19-19.9	1.21	....	....	....
20-20.9	1.24	$1.55	....	$1.42
21-21.9	1.28	1.57	....	1.44
22-22.9	1.32	1.59	....	1.46
23-23.9	1.35	1.61	....	1.48
24-24.9	1.39	1.63	$1.86	1.50
25-25.9	1.43	1.65	1.88	1.52
26-26.9	1.46	1.67	1.90	1.54
27-27.9	1.50	1.69	1.92	1.56
28-28.9	1.54	1.71	1.94	1.58
29-29.9	1.57	1.73	1.96	1.60
30-30.9	1.61	1.75	1.98	1.62
31-31.9	....	1.77	2.00	1.64
32-32.9	....	1.79	2.02	1.66
33-33.9	....	1.81	2.04	1.68
34-34.9	....	1.83	2.06	1.70
35-35.9	....	1.85	2.08	1.72
36-36.9	....	1.87	2.10	1.74
37-37.9	....	1.89	2.12	1.76
38-38.9	....	1.91	2.14	1.78
39-39.9	....	1.93	2.16	1.80
40 and above	....	1.95	2.18	1.82

*For crude from Daboval, El Campo, and Sandy Point. †Includes Lea County, New Mexico.

(Quotations shown here are f.o.b. plant in tank cars and in cents per gal. as of last Monday.

REFINERY GASOLINE

Octane (A.S.T.M.)	78-80†	73-75
Mid-Continent*	7.875-8.125	8.500-9.000
Tex. Gulf Coast	7.750-8.000	8.375-8.750
New York Harbor	9.4-11.2	8.4-9.7

*Basic Oklahoma Group 3. †1939 C.F.R. (research method).

NATURAL GASOLINE

Grades—	26-70	18-55
Oklahoma (Group 3)	5.125	6.150
N. Texas (f.o.b. plant)	4.625	5.550
N. Louisiana (f.o.b. plant)	4.875	5.850

CRUDE-OIL PRICES

Representative posted schedules per bbl.

East Texas	$1.95
Kettleman Hills, California*	1.69
Beauregard Parish	1.90
Illinois Basin	2.07
Pecos County, Texas (Yates)	1.65
Bradford, Pennsylvania	3.65
Eastern Ill. and Western Ind.†	2.07
Tomball, Texas Gulf Coast	2.10

*Crude prices exclusive of subsidy †35° and above.

A.P.I. REFINERY REPORT

Week ended March 8, 1947
(Figures in thousands of barrels)

	Dly. crude runs to stills	Stocks— Gaso-line	Dis-tillate	Resid-ual
East Coast	777	23,001	11,870	6,467
Appalachian	158	3,815	437	313
Ill., Ind., Ky.	855	22,244	2,543	2,280
Okla., Kan., Mo.	398	10,638	1,250	952
Inland Texas	223	4,640	312	811
Tex. Gulf Cst.	1,156	15,225	6,615	5,166
La. Gulf Cst.	354	5,354	2,124	1,534
N. La., Ark.	62	2,000	462	130
Rocky Mtn.	130	3,060	503	794
California	816	16,441	10,485	25,755
Total 3-8-47	4,935	106,418	36,601	44,202
Total 3-1-47	4,896	105,803	38,004	45,175
Total 3-9-46	4,664	105,041	25,705	38,404

CRUDE-OIL STOCKS

(Bureau of Mines Estimate)

Week ended:	Bbl. of crude*
March 8, 1947	223,679,000
March 1, 1947	225,131,000
March 9, 1946	226,112,000

*Excludes unrefinable Calif. stocks.

TRENDS

DAILY AVERAGE PRODUCTION FOR WEEK

	Mar. 15 crude oil	B. of M. Mar. demand	Mar. 8 crude oil
Alabama	950	1,200	950
Arkansas	79,900	79,000	80,750
California	914,000	850,000	899,500
Colorado	37,250	38,000	38,020
Eastern	57,500	64,200	61,000
Florida	590	200	125
Illinois	190,500	210,000	193,600
Indiana	16,900	18,000	17,300
Kansas	260,700	270,000	255,550
Kentucky	26,800	29,000	26,600
Louisiana	414,050	400,000	413,150
North Louisiana	102,600	.....	101,700
South Louisiana	311,450	.....	311,450
Michigan	42,155	47,000	43,405
Mississippi	83,345	77,000	87,295
Montana	22,780	24,000	22,560
Nebraska	650	700	700
New Mexico	103,900	101,000	103,900
Oklahoma	367,450	375,000	366,400
Texas	2,129,750	2,060,000	2,129,750
District 1 (Southwest)	20,550	.....	20,550
District 2 (Southwest)	157,900	.....	157,900
District 4 (Southwest)	242,000	.....	242,000
District 3 (Gulf Coast)	487,300	.....	487,300
District 5 (Eastern)	38,290	.....	38,290
District 6 (Eastern)	110,995	.....	110,995
East Texas field	313,000	.....	313,000
District 7-C (West)	34,892	.....	34,892
District 8 (West)	473,725	.....	473,725
District 7-B (W. Central)	36,425	.....	36,425
District 9 (N. Central)	130,000	.....	130,000
District 10 (Panhandle)	84,675	.....	84,675
Wyoming	104,770	100,000	106,320
Miscellaneous	.....	700	.....
Total United States	*4,853,940	4,745,000	4,846,875
Change from prev. week	up 7,065		

Total production January 1-March 15 ..... †352,336,895 bbl.
Same period last year (crude plus condensate) . 348,563,740 bbl.
*Not incl. 25,000 bbl. condensate. †Incl. 1,898,080 bbl. condensate.

CRUDE-OIL STOCKS 223,679,000 bbl. as of March 8,—down 1,452,000 bbl. One year ago 226,112,000 bbl.

GASOLINE STOCKS 106,418,000 bbl. as of March 8—up 615,000 bbl. One year ago 105,041,000 bbl.

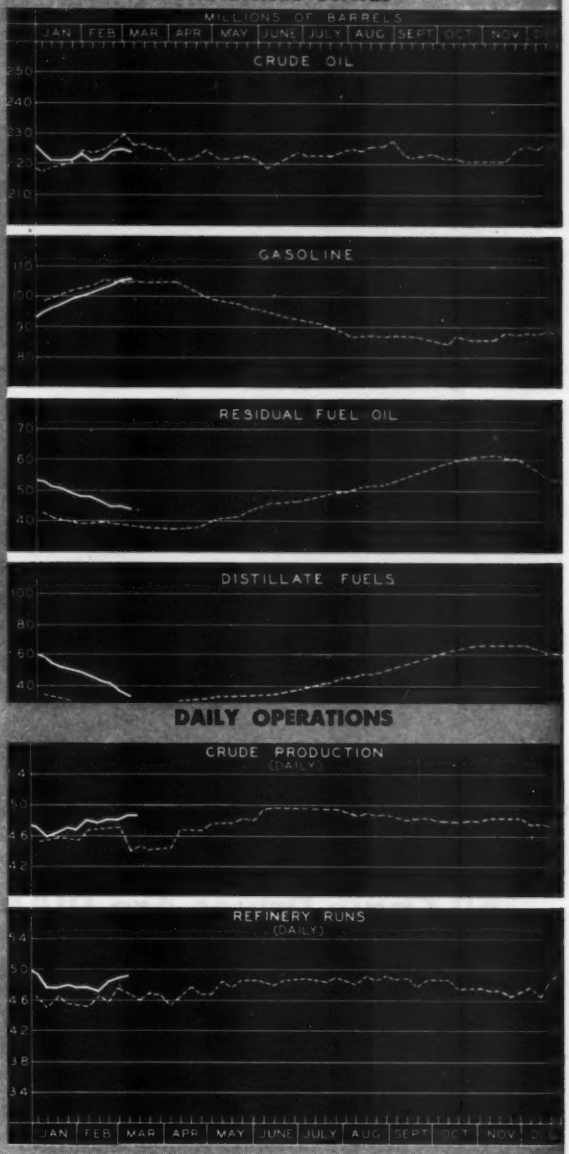
RESIDUAL FUEL-OIL STOCKS 44,202,000 bbl. as of March 8—down 973,000 bbl. One year ago 38,404,000 bbl.

GAS OIL AND DISTILLATE STOCKS 36,601,000 bbl. as of March 8—down 1,403,000 bbl. One year ago 25,705,000 bbl.

CRUDE-OIL PRODUCTION 4,853,940 bbl. as of March 15—up 7,065 bbl. One year ago 4,404,330 bbl.

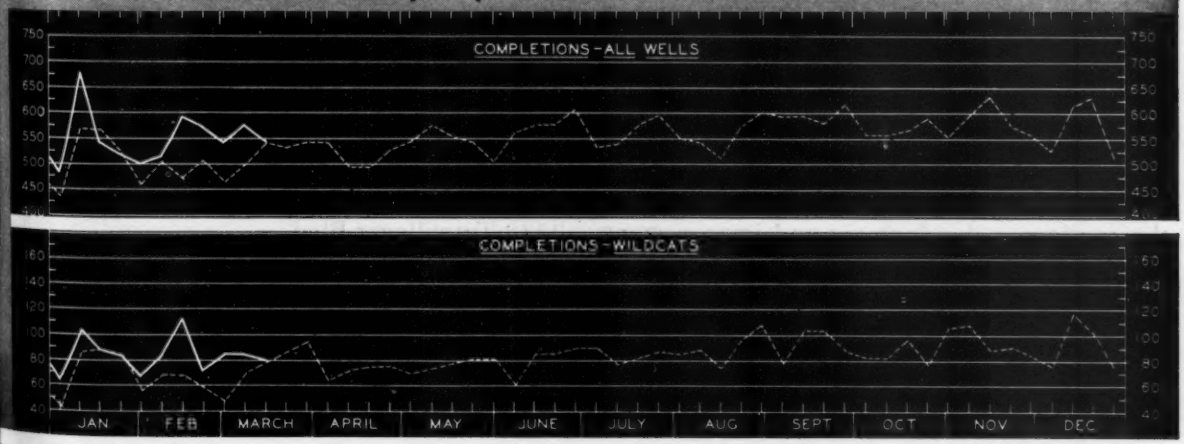
REFINERY RUNS 4,935,000 bbl. daily week ended March 8—up 39,000 bbl. One year ago 4,664,000 bbl.

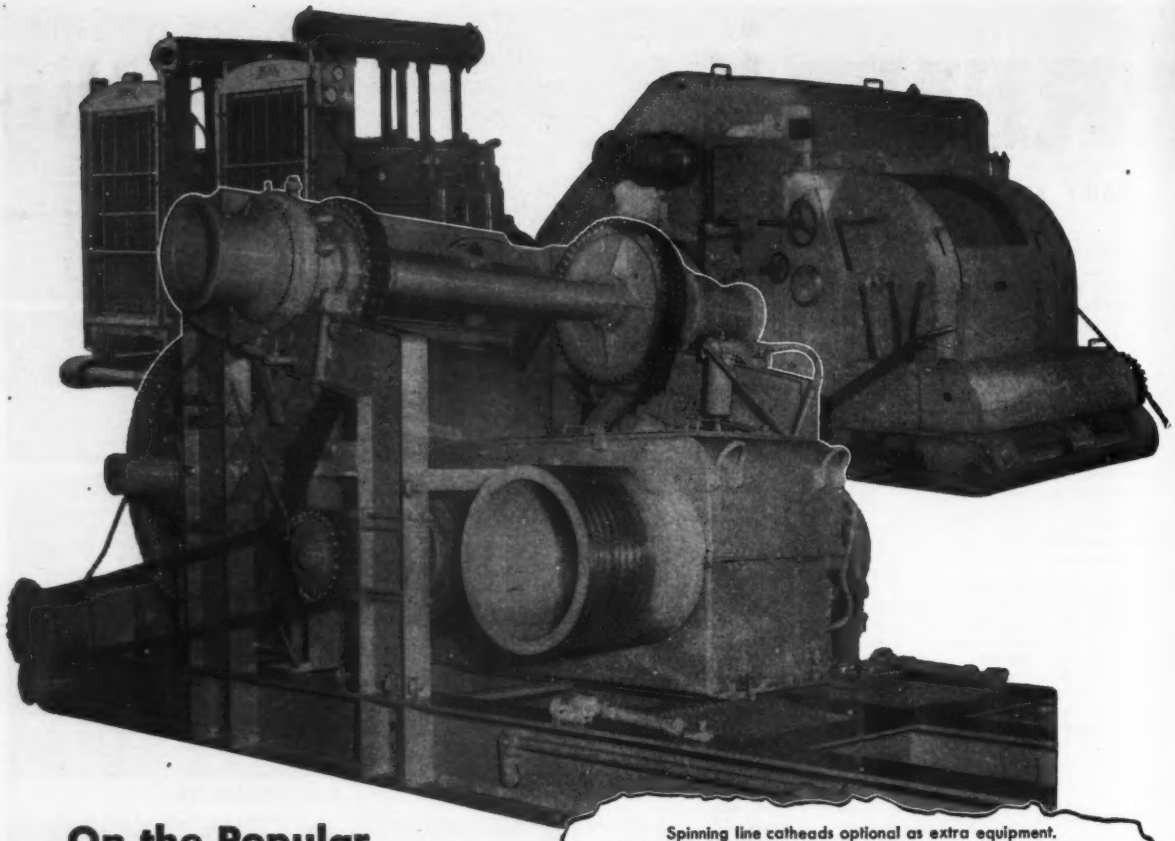
OIL STOCKS IN THE UNITED STATES



DAILY OPERATIONS

Solid line charts weekly completions, service wells in Eastern area included.





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SPROCKETS: Machine-cut steel; large sprockets demountable; small sprockets heat-treated.

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Greater well drilling and servicing depths and the need for steady uninterrupted operation have made chain drive ruggedness and dependability of greater importance than ever before.

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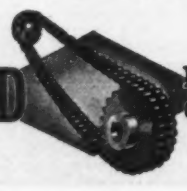
Engineers, machinery designers and manufacturers of greatest experience assure maximum performance with DIAMOND Roller Chains. Machinery buyers recognize them as an indication of sound engineering. DIAMOND CHAIN COMPANY, Inc., Dept. 475, 402 Kentucky Ave., Indianapolis 7, Indiana. *Tulsa Office:* 2238 Terwilleger Blvd.



DIAMOND ROLLER CHAINS

Exploration and Drilling

Major Pool Looms in Oklahoma

CONVINCING evidence that a major pool was in the making in Garvin County, Oklahoma, was brought into the picture last week, when Anderson-Prichard et al 1 Seaton, SE SE NW 14-2n-2w, on drillstem test flowed 50 to 100 bbl. per hour of 42°-gravity oil from a Pennsylvanian sand at 6,411-18 ft.

The well is 3½ miles southeast of the Southwest Antioch pool and 4½ miles northwest of the Katie pool, both of which produce from the Pennsylvanian at about this horizon. For some time a substantial number of geologists have been speculating on the possibility of Antioch and Katie pools connecting. Now the number of doubters has diminished almost to the vanishing point.

The general picture, with accurate limits not yet defined, is that of the Pauls Valley uplift forming a nosing to the northwest; around the rim, partway on the flank, a belt of Pennsylvanian-sand deposition, which appears to carry oil. How far this sand deposition is continuous, and whether it will carry oil continuously remains to be determined. Right now it looks as though there was an excellent chance of a sand belt, perhaps 10 to 12 miles long, of undetermined but probably narrow width, forming one field.

It is true that the oil at Southwest Antioch and that at Katie, when "fingerprinted" by the correlation index number system based on Bureau of Mines Hempel analysis method, indicates substantial differences. Therefore, there is a chance that the fields may be separate. No correlation index number pattern on the Anderson-Prichard well, midway between the two fields, is available as yet.

On the other hand, the general sedimentary environment that must have existed during the accumulation and perhaps formation of the oil, could have been such that the organic debris and other factors presumably affecting the type of oil, might have varied sufficiently in the distance between the two areas to account for the differences in the oil found so far. There has not been sufficient published information on work with the correlation index number system in long stratigraphic-trap type fields to establish whether such differences are possible.

It is difficult to see how interest in the Garvin-McClain county area could be increased much more, yet that will undoubtedly be the case. The number of strikes within the past 2 years in this general play, and the more encouraging results of recent months and weeks, will certainly bring even more drilling rigs into the area and more operators. The operators now active all are beginning to get a much more accurate control on the whole region and their geologists should be able to make sharper local interpretations.

EASTERN TEXAS

Operators Testing In Anderson County

DALLAS.—In Anderson County, 5 miles southwest of Elkhart, Blue Bird Investment Co. 1 J. H. Pierson made an estimated flow of 25,000 000 to 30,000,000 cu. ft. of gas a day, with distillate running about 4 bbl. per 1,000,000 cu. ft. The flow was from perforations in the Woodbine at 5,504-20 ft. Casing pressure was 2,100 lb., and tubing pressure 1,950 lb. Total depth is 5,706 ft. Operators were continuing tests.

Three miles south of Texarkana, Bowie County, Barnsdall Oil Co. 1 J. R. Greenwood was drilling below 8,020 ft. in shale and limestone after finding small shows of oil in cores. At 7,640-70 ft. cores showed hard, tight limestone, with a show of oil, but at 7,668-71 ft. recovery was dense, varicolored limestone with no shows. Formation tops were Paluxy 3,000 ft., massive anhydrite 4,396 ft., Pettit 5,146 ft., Travis Peak 4,240 ft., Cotton Valley 6,150 ft., and Smackover 7,660 ft.

Standard Oil Co. of Texas continued to test the 1 New Birmingham, northwest of Maydell in Cherokee County. Perforations in the James limestone at 9,092-9,168 ft. resulted in swabbing wash water, acid water, and a slight show of gas. Operators were swabbing at 3,000 ft.

In the Opelika field, Henderson County, Lone Star Producing Co. 1 Anglin, seeking production from the Travis Peak, plugged back from 9,759 ft. to 9,497 ft. and completed for 246 bbl. of oil a day. Flow was through ¼-in. choke from perforations in the Rodessa section at 8,904-22 ft. Freestone County's deep test, The Texas Co. 1 W. M. White, 3 miles west and slightly south of Fairfield, had total depth at 13,508 ft. in limestone, and on last report was washing over drill collars at 13,326 ft.

In Harrison County, Edgar C. Johnston's 2 Cargill, Simpson Holloway Survey, has completed as the largest gas-condensate well in the Waskom area, it was said. It was reported to have gaged 100,000,000 cu. ft. of gas daily from the Pettit zone at 5,650-5,750 ft., and 20,000,000 cu. ft. of gas daily from the Travis Peak. Total depth is 6,200 ft. The amount of condensate was not gaged.

EAST TEXAS WILDCAT FAILURE

Anderson County: Yeakley Drilling Co. 1-A C. C. Waits, R. Allen Sur., J. I. Aguilera League, dry, TD 1,852 ft.

N. CENTRAL TEXAS

Parker County Well May Open Gas Field

WICHITA FALLS.—Prospects for another gas field that would extend the northeastern end of a northeast-southwest trend through several counties, was reported last week. Crader Oil Co., Fort Worth, 1 O. V. Sneed, Section 321, T&P Survey, in the Garner townsite of northwestern Parker County, was said to have found a gas sand at 3,133-48 ft., estimated to be capable of making 1,000,000 cu. ft. of gas a day. Details were not available.

A new gasser was reported for southwest Young County, 7½ miles northwest of Eliasville. Warren Oil Corp. 1 Bulah Martin perforated casing at 4,212-17 ft. in an unidentified formation and tested at the rate of 12,900,000 cu. ft. of gas a day.

In Throckmorton County, Fred M. Manning, Inc., 1 R. A. Brown Cattle Co. extended the new Record (Mississippi limestone) area ½ mile to the northeast. Drilled to 4,154 ft., 20 ft. in the Caddo limestone, a 1-hour drill-stem test brought gas to the surface in 6 minutes, with total recovery being 1,000 ft. of oil. Flowing pressure was 200 lb., while bottom-hole pressure rose to 1,800 lb. in 15 minutes. This test was correlating about even with the Record discovery and operators were to carry it on to the Mississippian, or to around 4,500 ft. This test was said to have found a good show of oil in the Strawn around 3,000 ft., and again in the Caddo at 3,860-80 ft. However, a drill-stem test at the latter interval recovered 30 ft. of mud. Other shows of oil were reported at 3,996-4,017 ft. and 4,108-4,115 ft. Also in the southeastern part of the county, Mudge Oil Co.'s 1 M. K. Graham, located 2 miles northeast of the Magnolia-Graham field, topped Mississippian limestone at 4,680 ft., reported showings of oil from 4,682-4,702 ft., total depth. A drill-stem test at that depth recovered 30 ft. of oil-cut mud. Operators set casing to 4,680 ft. Rotary tools were moved out and cable tools set up for drilling plug.

NORTH CENTRAL TEXAS SUCCESSFUL WILDCATS

Archer County: H. W. Snowden 1 J. H. Turbeville, J. B. Hinds Sur., 4 mi. SE Anarene, pumped 120 bbl. a day, Caddo 4,548 ft., TD 4,672 ft., PB 4,620 ft.

Clay County: Reeves-Ely Laboratories, Inc. 1 L. T. Burns, J. H. Belcher Subd., 4 mi. NW Joy, pumped 64.6 bbl. 40° gravity, shot sand 4,945-70 ft., TD 6,152 ft.

Jack County: Warren Oil Corp. 1 J. P.

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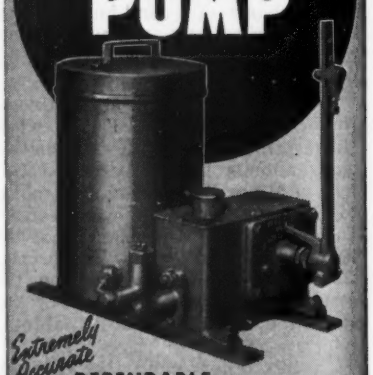

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Cantrell, Sec. 2, SPRR Sur., 6 mi. S Antelope, flowed 68 bbl. 42°-gravity oil in 3 hours, Caddo 4,722-4,746 ft., TD.

NORTH CENTRAL TEXAS WILDCAT FAILURES

Archer County: P. C. Burns et al 1 C. L. Abercrombie, Hooper & Wade Sur., ½ mi. SE Archer City, dry, TD 1,119 ft. in shale.

L. H. Choate 2 Burk Warmuth, Clark & Plumb Subd., 2 mi. SE Scotland, dry, TD 292 ft.

L. Raymond Dawson, Jr. 1 Turbeville, J. W. Harris Subd., 10 mi. NW Archer City, dry, TD 1,520 ft. in shale.

Cooke County: Cities Service Oil Co. 1 H. A. Bezner, David Sackett Sur., 3 mi. W Gainesville, dry, TD 2,406 ft., Ellenburger 2,350 ft., elev. 751 ft.

F. R. Jackson 1 Boone Johns, James Chaffin Sur., 4 mi. E Valley View, dry, TD 2,214 ft. in limestone, Ellenburger 2,162 ft.

Denton County: The Texas Co. 1 J. A. Williams, Francisco Travino Sur., 11 mi. NE Denton, dry, TD 2,440 ft. in limestone.

WEST CENTRAL TEXAS WILDCAT FAILURE

Throckmorton County: Woodley Petroleum Co. 1 J. T. O'Dell, Sec. 695, TE&L Co. Sur., 3½ mi. SW Woodson, dry, TD 4,940 ft., Caddo 3,916 ft., Ellenburger 4,830 ft., elev. 1,253 ft.

TEXAS GULF COAST

Victoria County Test Opens New Pay Zone

HOUSTON.—A new oil pay zone for West Pridham Lake field in Victoria County has been opened by Fidelity Oil & Royalty Co. 1 Edward Dietzel. The new pay was topped at 2,954 ft. and well was completed flowing 83 bbl. of oil per day through a 5/32-in. choke through perforations at 2,959-61 ft. Total depth is 4,973 ft. with 5½-in. casing at 3,010 ft. This well is located in the east corner of a 125-acre lease in R. Manchola Grant, Abstract 87.

The Texas Co. 1 George E. Scott et al, is a new gas discovery in Victoria County, approximately 8½ miles northwest of Inez. Drilled to a total depth of 4,532 ft., this well was estimated good for 18,000,000 cu. ft. of gas per day on open flow through perforations at 4,110-20 ft. The 5½-in. casing was set on bottom. This new discovery is located in the William Minter Survey, Abstract 264, 8 miles northeast of Telferner field and 5 miles west of Edna gas field of Jackson County.

Hewitt & Dougherty 1-A Kathleen D. Roache is being completed as a new oil-pool discovery in Refugio County, approximately 4 miles southwest of Woodsboro and 3¾ miles northwest of LaRosa field in D. J. Mitchell Survey. On a drill-stem test at 6,813-18 ft. in open hole, through ¼-in. chokes top and bottom, it developed 165 lb. working pressure in 15 minutes and recovered 900 ft. of pipe-line oil with 2,325-lb. bottom-hole pressure flowing. Total depth is 6,818 ft. and 5½-in. casing was set on bottom. On a previous test at 6,766-73 ft. it recovered 60 ft. on condensate in 10 minutes, working pressure 750 lb. Operators have perforated for completion.

Cockburn Oil Corp. 1 Wharton Bank & Trust Co., wildcat 3 miles south of Lane City townsite and 3½ miles northeast of nearest production in Withers field in Wharton County, is running 5½-in. production string to around 4,600 ft. to test a possible new oil-producing level in the 4,500-ft. level. Total depth is 5,650 ft. This test is located in the AB&M Survey 2.

Mac Drilling Co. 1 Cynthia Payne, Vital Flores Survey, 5 miles west-southwest of Cold Springs field, 4 miles south of Evergreen townsite in San Jacinto County, is a potential new field opener. New oil production was indicated last week on a drill-stem test at 7,688-7,700 ft. in the upper Wilcox sands, recovering 12 stands of oil and gas with no water. Test started flowing with 1,600-lb. bottom-hole flowing pressure which built up to 2,000 lb. in 20 minutes and up to 3,100 lb. when shut in. Operators are drilling ahead just below 8,082 ft. and will go to the projected depth of 8,250 ft., where log will be run.

There were 35 new locations for the Texas Gulf Coast district this week, including 12 wildcat starts, 2 each in Goliad and Harris, and 1 each in Bee, Brazoria, Burleson, Calhoun, Jackson, Karnes, and San Jacinto counties. There were five successful exploratory tests completed, two in Victoria and one each in Bee, Colorado, and Harris counties. The six dry wildcats include two in Wilson and one each in Bee, Fort Bend, Karnes, and Wharton counties.

TEXAS GULF COAST SUCCESSFUL WILDCATS

Bee County: New gas-condensate pool—Tom Slick 1-D Slick fee, in J. Richardson Sur., Abst. 393, 1 mi. NW of Burnell-Wilcox field, and ½ mi. NE of South Caesar field, TD 6,637 ft., top pay 6,524 ft. (Slick sand) perf. 6,524-25½ ft., IP: gas-condensate well, no gage, TP 2,000 lb., CP 2,400 lb. (amber condensate), no water.

Colorado County: New gas pay, Sublime field—Tide Water Assoc. Oil Co. 1 Guy F. Stovall, in M. Muldoon Sur. 30, TD 9,700 ft., perf. 8,034-39 ft. IP: flowed gas and shut in, no gage, TP 2,275 lb., no water.

Harris County: New gas-condensate production West Flank Esperson Dome—Eli Marks 1 A. B. Cohn Estate, Meredith Duncan Sur., ¾ mi. W of production at Esperson Dome, TD 9,094 ft., perf. 8,687-95 ft., IP: flowed gas and

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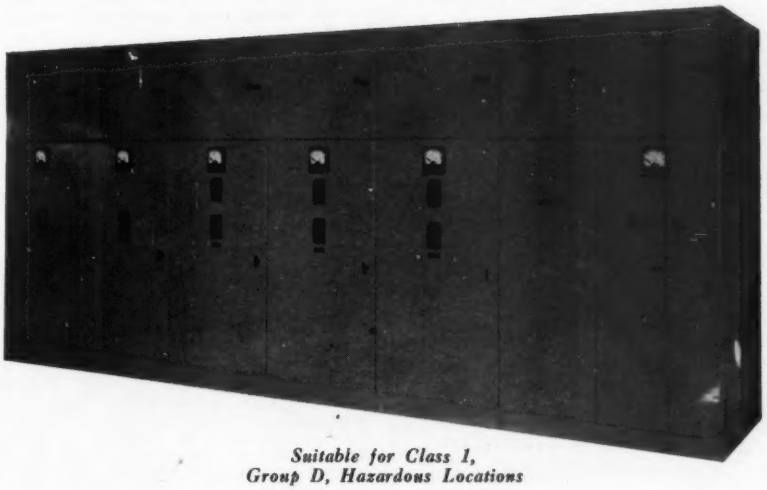

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condensate, no gage, shut in, TP 3,000 lb., gravity 50°, no water.

Victoria County: New oil pay, West Pridham Lake pool—Fidelity Oil & Royalty Co. 1 Edward Dietzel, in R. Manchola Grant, TD 4,973 ft., top pay 2,954 ft., perf. 2,959-61 ft., IP: 83 bbl. oil per day through 5/32-in. choke, gas-oil ratio 35, TP 145 lb., CP 435 lb., gravity 21.3°, 0.1 per cent water.

New gas pool—The Texas Co. 1 George E. Scott et al, Wm. Minter Sur. A-264, 8½ mi. NW of Inez, 8 mi. NE of Telferner field, TD 4,532 ft., top pay 4,110 ft., perf. 4,110-20 ft., IP: 18,000,000 cu. ft. gas per day on open flow, shut in, no water.

TEXAS GULF COAST WILDCAT FAILURES

Bee County: Herb E. Dirks and Phillip D. Gully 1 J. O. Harris, J. H. Harris subd., in Henry Coley Sur., 1½ mi. NW of Mineral, dry, TD 4,260 ft.

Fort Bend County: Brewster & Bartle 1 Perry V. Cook, 4 mi. S of Katy gas production on SE side of Fulshear Prospect, Alex Phillips Sur., dry, TD 8,012 ft.

Karnes County: W. Earl Rowe et al 1 W. S. Cochran et al, in M. B. Morrison Sur. A-405, 3 mi. NE of Gillette, dry, TD 4,039 ft.

Wharton County: The Sparta Oil Co. 1 Taylor D. Kemp, Sr. et al, in S. F. Austin 3-1/6th Lge. grant, ½ mi. S of Boling Dome production, dry, TD 6,240 ft.

Wilson County: C. Andrade III 1 Thaddeus Kopecki, A. Barrera Sur. 14, 6 mi. NE of Poth, dry, TD 6,356 ft.

Mid-Continent Pet. Corp. and W. C. McBride, Inc. 1 W. F. Gabrysch, in Louis Manchaca Grant, 3.7 mi. NW of Falls City, dry, TD 6,515 ft.

APPALACHIAN FIELD

Three Chestnut Ridge Wildcats Top Tully Lime

PITTSBURGH. — On Chestnut Ridge in Georges Township, Fayette County, three wildcats topped the Tully Lime. Manufacturers Light & Heat Co. topped the Tully at 6,263 ft. on Jesse S. Eutsey farm from a surface elevation of 2,290 ft., placing it minus 3,973 ft. This is an offset not too close, to the large Onondaga chert gas well on the J. R. Smith farm which logged the top of the Tully Lime at 6,280 ft., 17 ft. lower than the new test. Here Peoples Natural Gas Co. topped the Tully at 6,560 ft. in another offset on W. M. Hartman farm, and in a second test on the George Walters farm topped the Tully at 6,944 ft. The No. 1 George Walters was dry.

In Summit Township, Erie County, Sylvania Corp. topped the Onondaga Lime at 2,121 ft. in the wildcat on Alton F. Hugger farm.

New locations totaled seven in Plum Creek and Valley townships, Armstrong County; German Township, Fayette County; Porter Township, Clarion County, and Bell and Derry townships, Westmoreland County.

In Logan district, Logan County, West Virginia, Columbian Carbon Co. completed 935 Island Creek Coal Co. as a large Big lime well gaging 9,205,000 cu. ft. of gas after acidizing. From surface elevation of 761 ft. the Big lime was topped at 1,590 ft., show of oil 1,415 ft., gas 1,769-82 ft. (gage 1,417,000 cu. ft.), acidized, rock pressure 580 lb. 24 hours, total depth 1,858 ft. The No. 928 Island Creek Coal Co. of this company just completed was dry through the Berea and plugged, total depth 2,525 ft.

In Reedy district, Wirt County, McCall Drilling Co. completed another good Berea well in No. 234 F. S. Enoch which gaged 1,112,000 cu. ft. gas, natural; Berea 2,377-90 ft., gas 2,380 ft., rock puressure 480 lb. 12 hours, total depth 2,392 ft.

In Baileysville district, Wyoming County, West Virginia, Hope Natural Gas Co. completed 9,060 New River and Pocahontas Consolidated Coal Co. with a final gage after shot of 1,887,000 cu. ft. Surface elevation 1,674 ft., Ravenwood sand 1,682-1,740 ft., show gas 1,705 and 1,726 ft., Big lime 2,720-3,140 ft., Berea 3,795-3,820 ft., gas 3,804-20 ft., gaging 1,009,000 cu .ft. before shot, rock pressure 620 lb. 17 hours, total depth 3,825 ft.

In Ripley district, Jackson County, Columbian Carbon Co. is drilling through the Oriskany sand in the test 929 Frank Walters with 3,610,000 cu. ft. of gas 12 ft. in the sand. In Ravenswood district this company topped the Corniferous lime at 4,842 ft. in the test 933 J. M. Sullivan.

MICHIGAN

Discovery Holds Attention Of Michigan Operators

SAGINAW.—A western Michigan discovery held attention of Michigan oil operators as Sun Oil Co. 1 Linderer in Section 11 of Garfield Township, Newaygo County, continued to flow by heads at around 100 bbl. per day. The wildcat, producing from Traverse limestone at 2,336 ft., came in at an initial estimated flow of 500 bbl. per day.

Only two other completions were reported for the week and both were producers. One, Gordon Oil Co. 3 Keef in Clayton Township, Arenac County, had estimated initial daily capacity of 1,200 bbl. after being acidized. The other, Sun Oil 35 Horner in Section 16 of the Missaukee County Norwich field, was rated at 60 bbl. a day after acid treatment. It was a deep

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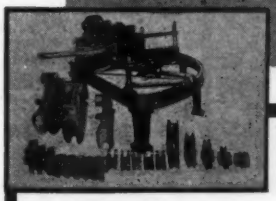

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formation producer completed at 4,451 ft.

There were five new locations on the books. They were listed for Allegan, Isabella, Lapeer, Montclam, and Ottawa counties.

MICHIGAN SUCCESSFUL WILDCAT

Newaygo County, Garfield Township: Sun Oil Co. 1 Linderer, SW SW SW 11-12n-13w, flowing 100 bbl. a day from Traverse limestone, TD 2,336 ft.

SOUTHWEST TEXAS

Starr County Gets Kennard Pool Opener

CORPUS CHRISTI. — The new Kennard oil pool in Starr County has been opened by Coastal Refineries, Inc. and W. D. Kennard 1 George Coates-T. E. Vessels, Jr., in Tract 5, Porcion 93, east of Boyle field, and south of Rincon field. Drilled to a total depth of 4,319 ft., pay was topped at 3,870 ft., and on initial test flowed 38 bbl. of oil per day through a 3/16-in. choke, gas-oil ratio 400, tubing pressure 50 lb., casing pressure 430 lb. Gravity is 45.6°. Production is through perforations at 3,870-82 ft. Coastal and Kennard have completed the second well for this new field. The 1 M. M. Garcia, Tract 1, Porcion 93, was completed for potential of 82 bbl. of oil per day through a ¼-in. choke through perforations at 3,852-62 ft. Total depth is 4,114 ft.

A new, deeper gas-condensate sand for the North Sun field in Starr County, has been opened by Sun Oil Co. 4 Lee M. Green, located in the Santa Teresa Grant. On initial test it flowed 2 bbl. of condensate per day through a 9/64-in. choke, with 1,180,000 cu. ft. gas with tubing pressure 2,250 lb., casing pressure 2,500 lb. Total depth is 6,995 ft., with 5½-in. casing at 6,596 ft. Production is through peforations at 6,470-80 ft.

Coastal Refineries, Inc. and Cook-Thompson 1 Mrs. Zillah Hansen, new deep-pay discovery at McAllen gas-condensate field, Hidalgo County, ran potential gage of 10,000,000 cu. ft. gas per day on open flow, with gas-condensate ratio of 53,012, or about 85 bbl. of condensate per day on 3/16-in. choke, with 4,500,000 cu. ft. gas. Production is through perforations at 10,090-180 ft. Total depth is 11,101 ft., and test is located in Steele & Pershing Subdivision in Porcion 67.

Dee Davenport 1 Davenport-State, wildcat 1½ miles north of Frost field, Survey 974, in Starr County, is reported completed as a good gas-condensate well flowing light-colored oil or condensate through perforations at 4,098-4,110 ft. Total depth is 5,501 ft.

Magnolia Petroleum Co. 1 William McKinley, wildcat in Frio County, 6½ miles northeast of Pearsall in M. C. Davidson Survey, recovered 40 ft. of oil-cut mud in 20 minutes on drill-stem test at 5,604-11, through ¼-in. chokes top and bottom. Operators are drilling ahead to a scheduled depth of 12,000 ft.

B. C. Graham and Cam Corp. are preparing to complete their 2 Rosa V. de Benavides as an oil discovery in the Cam area of Duval County. On drill-stem test at 2,640-48 ft. this well flowed pipeline oil in 22 minutes, 180 lb. working pressure, through ¼-in. and ⅛-in. chokes. Total depth is 3,365 ft., with 5½-in. casing set on bottom.

Humble Oil & Refining Co. 1 Emelia Lujan et al, wildcat northeast of Charlotte, in Atascosa County, has been completed dry at a total depth of 7,119 ft. in anhydrite and chert, after it had indicated possible oil production on drill-stem test in the Edwards lime. Test at 7,010-19 ft. recovered 110 ft. of oil and 10 ft. of water and test at 7,012-24 ft. recovered 180 ft. of oil and 120 ft. of salt water. This test is located in the John Noble Survey 1438.

There were 23 new locations reported this week with 4 being wildcats, 1 each in Atascosa, Duval, Webb and Zapata counties. Five exploratory tests opened four new pays and one new pool. The new pays are in Hidalgo, Jim Wells, Nueces, and Starr counties, while the new pool is in Starr County. There were eight dry wildcats, two in Atascosa, and one each in Caldwell, Cameron, McMullen, Webb, Zapata, and Zavala counties.

SOUTHWEST TEXAS SUCCESSFUL WILDCATS

Hidalgo County: New condensate pay, McAllen field—Coastal Refineries, Inc. and V. E. Cook and Chas. E. Thompson 1 Mrs. Zillah Hansen, in Porcion 67, 1 mi. E of McAllen, TD 11,101, top pay 9,990 ft., perf. 10,090-10,180 ft., IP: 85 bbl. condensate per day through a 3/16-in. choke, gas-condensate ratio 53,012, gravity 50.3°, no water. On open flow gaged 10,000,000 cu. ft. gas per day, TP 4,200 lb., SIP 6,500 lb.

Jim Wells County: New gas-condensate pay, Alice field—Tom Graham 1 Trussell Unit 1, Share 6, La Vaca Grant, TD 7,809 ft., perf. 4,338-52 ft., IP; gas-condensate well on 3/16-in. choke, no gage, TP 1,850 lb., CP 1,900 lb., no water.

Nueces County: New oil pay, Agua Dulce field—L. M. Lockhart 1 A. J. Till, in V. L. de Herrera Grant, TD 6,630 ft., top pay 6,618 ft., perf. 6,619-22 ft., IP: 155 bbl. oil per day through a 9/64-in. choke, gas-oil ratio 487, TP 950 lb., CP 1,200 lb., gravity 38.8°, no water.

Starr County: New oil pool (Kennard)—Coastal Refineries, Inc. and W. D. Kennard 1 Geo. Coates-T. E. Vessels, Jr., in Tract 5, Porcion 93, E of Boyle field and S of Rincon field, TD 4,319 ft., top pay 3,870 ft., perf. 3,870-82 ft., IP 38 bbl. oil per day through a 3/16-in. choke, gas-oil ratio 400, TP 50 lb., CP 430 lb., gravity 45.6°, no water.

New gas pay, North Sun field—Sun Oil Co. 4 Lee M. Green, in Santa Teresa Grant, TD 6,995 ft., perf. 6,470-80 ft., IP: 2 bbl. condensate per day through a 9/64-in. choke, with 1,180,000 cu. ft. gas per day, TP 2,250 lb., CP 2,500 lb., no water.

SOUTHWEST TEXAS WILDCAT FAILURES

Atascosa County: Humble 1 Emelia Lujan et al, in John Noble Sur. 1438, 1 mi. NE of Charlotte, dry, TD 7,119 ft.

H. R. Smith et al 6 Hurt & Tartt, in Jas. Wilkinson Sur. 144, 6,500 ft. SW of Weigand field, dry, TD 3,796 ft.

Caldwell County: C. H. Robertson 1 W. B. Walker et al, in Robt. Davidson Sur. 8 mi. NE of Luling, dry, TD 3,588 ft.

Cameron County: Magnolia & Abercrombie 1 Melvin Giese, Burton Subd. 3 on Ojo de Agua Grant, 4 mi. W of Sebastian, dry, TD 10,218 ft.

McMullen County: O. D. Edwards, Jr. 4 Annie Graves Dolph et al, in Francisco Gomez Sur., 13 mi. SE of Tilden, dry, TD 1,505 ft.

Webb County: Texas Co. 1 R. E. Welhausen, CCSD&RGNG, W. W. Griffin Sur. 28, 6 mi. NW of Lopez field, dry, TD 2,460 ft.

Zapata County: Wm. H. Spice, Jr. 1-A Albert Martin, Tr., in Blk. 24, Fansler-O'Hern Subd. of Cart Blanca Ranch, in Villa Grant, 2½ mi. SE of Comitas field, dry, TD 2,358 ft.

Zavala County: Texas Co. 1 W. L. Hardaway, Sec. 67, Cross S. Ranch Subd., Narcisco Aguirre Grant, 5 mi. NE of Crystal City, dry, TD 3,925 ft.

PERMIAN BASIN

Ector Well Recovers 1,900 Ft. of Oil in Test

MIDLAND.—Late last week, The Texas Co. 31-E W. E. Connell Estate, Section 29, Block B-16, Public School Lands Survey, Crane County, 3 miles west of new Ellenburger production at Penwell in southern Ector County, recovered 1,900 ft. of oil and 300 ft. of sulfur water on a drill-stem test of the Glorietta at 4,660-4,750 ft. Open 3 hours and 40 minutes, gas came to the surface in 12 minutes and flowed some 15,000 cu. ft. This test is contracted to 9,500 ft. to test the Ellenburger, and operators were drilling ahead. Location is 3¼ miles south of the same company's 29-E Connell, which was dry in the Ellenburger and recovered only 15 ft. of free oil from the Glorietta at approximately the same depth. It was plugged back but failed on production tests.

Gulf Oil Corp. 1-HH University, east-central Crane County wildcat, some 11 miles north of Crane and 3½ miles north

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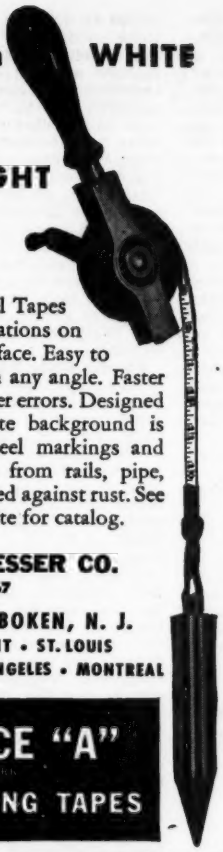

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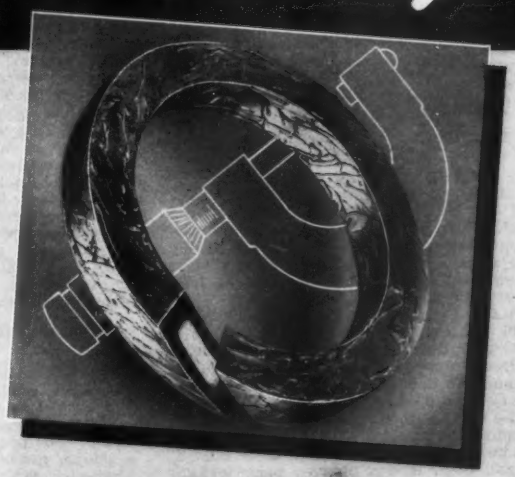

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of the Block 31 field, was drilling below 10,139 ft. on last report. This test has shown for production from the Devonian and Silurian, and the last reported drill-stem test showed possibilities in the Simpson group of the Ordovician. This test, at 9,995-10,070 ft., open 1 hour and 45 minutes, produced a steady blow of air for the first 35 minutes and a blow of gas for the remaining time. Total recovery was 852 ft. of fluid. Of that total, 282 ft. of mud was 80 per cent oil, and another 188 ft. of mud tested only 10 per cent oil. Gravity of the oil was 43.6°.

WEST TEXAS WILDCAT FAILURE

Borden County: Ed McAdams et al 1 Clayton & Johnson, Sec. 20, Blk. 31, T&P Sur., 4 mi. W and 1 mi. N Gail, dry, TD 3,711 ft., no tops reported.

SOUTHEASTERN NEW MEXICO

HOBBS.—T. G. Shappell 1 Bradley, NW NW NW 13-24s-26e, 1 mile north of the Black River area discovery, Eddy County, reported 400 ft. of 41°-gravity oil in the hole from a shallow sand. Operators were running tubing to test. Total depth is 1,967 ft., still in the sand.

In Lea County, north of Maljamar, Emperor Oil Co. 1 State, SW SW 32-16s-31e, had total depth at 4,500 ft., in the San Andres, topped at 3,945 ft. Operators swabbed it down in 6 hours and the recovery was 9 bbl. of oil. It was shot at 4,325-4,425 ft., then plugged back to 3,890 ft. and shot at 3,863-90 ft. Cleaned out to bottom, it flowed one head of 9 bbl. of oil and died. It was plugged back to 3,850 ft. for further tests.

North of Hardy field, Mid-Continent Petroleum Co. 1 State, SW SW 16-21s-37e, took a drill-stem test at 6,588-6,700 ft. Open 2½ hours, it flowed at the rate of 277,000 cu. ft. of gas a day, and when pipe was pulled unloaded 3,060 ft. of gas-cut mud and 180 ft. of oil. Flowing bottom-hole pressure was 1,200 lb., shut-in pressure 2,500 lb.

SOUTH LOUISIANA

Cameron Parish Gets Gas-Condensate Well

NEW ORLEANS.—New gas-condensate production for Cameron Parish has been opened by Magnolia Petroleum Co. 1-C Lutcher, 24-14s-11w, 4 miles northeast of Mud Lake gas and condensate production and 1½ miles off the southwest shore of Calcasieu Lake. It flowed into pits cleaning through a 6/64-in. choke with 3,400 lb. flowing pressure on the tubing. Production is through perforations at 11,272-309 ft. Sands are in a broken section between 11,200-310 ft. Total depth is 11,705 ft.

Also in Cameron Parish, Sohio Petroleum Co. 1 Charles Richard, 1-15s-5w, discovery in the Grand Chenier area, made an 11½-hour drill-stem test with 5/32-in. choke which flowed gas with a spray of condensate through perforations at 8,370-80 ft. Flowing pressure on the tubing was 3,100 lb. Total depth is 11,020 ft., and 5½-in. casing is cemented at 8,542 ft. Producing sands showed in sidewall samples taken from 8,367-99 ft.

Humble Oil & Refining Co. 10 Petit Anse Co., Inc., is new sand producer in the Avery Island field of Iberia Parish, in 26-13s-5e. Drilled to a total depth of 8,077 ft. in salt, sand was topped at 7,260 ft. and production is through perforations at 7,260-7,320 ft. Potential was 211 bbl. per day through a 9/64-in. choke, tubing pressure 1,290 lb., gas-oil ratio 700, gravity 35°, with 0.1 per cent water in the flow.

Sohio 4-B Claudius Fontenot, deep test ¼ mile south of production on the west side of Bon Air field in Jefferson Davis Parish, 16-10s-6w, flowed gas from another deep sand level. On test through perforations at 10,380-396 ft. it flowed 1,155,000 cu. ft. of gas daily with 5.7 bbl. of condensate daily through a ½-in. choke. Gas ratio 202,000. Flowing pressure on tubing 3,550 lb. On a previous test through perforations at 10,520-530 ft., it was reported to have flowed at the rate of 225 bbl. of oil, 31° gravity, daily, later going to gas and salt water. Operators have been unsuccessful in attempts to get the well to flow oil again from this depth, and perforations were squeezed. Total depth is 10,660 ft., and 5½-in. casing is cemented to the bottom.

Magnolia Petroleum Co. 1 State on Lease 684, Block 94, 30 miles offshore, St. Mary Parish, has set piling and now is building platform. This well is located in 22 ft. of water and is projected to 3,500 ft.

The 14 new locations reported this week for South Louisiana included 4 wildcat starts, 1 each in Avoyelles, Plaquemines, St. Landry, and St. Mary parishes. The completions included three wildcats, one new pay was opened in St. Martinville field, St. Martin Parish, and two were dry, one each in Terrebonne and West Baton Rouge parishes.

SOUTH LOUISIANA SUCCESSFUL WILDCAT

St. Martin Parish: New oil sand, St. Martinville field—Continental Oil Co. 4-A fee, 57-11s-6e, TD 4,992 ft., top sand 4,687 ft., perf. 4,688-4,700 ft., IP: 68 bbl. oil per day through a 7/64-in. choke, gas-oil ratio 1,662, TP 1,500 lb., gravity 28.3°, no water.

SOUTH LOUISIANA WILDCAT FAILURES

Terrebonne Parish: Pan American Production Co. 1 Claude P. Boudreaux, in Lake Quitman area, 2-19s-17e, 4 mi. NE of DeLarge gas field, dry, TD 14,012 ft.

West Baton Rouge Parish: Phillips Pet. Co. 1 Wilbert, in 33-7s-11e, 3 mi. SW of West Port Allen production, dry, TD 10,522 ft.

ROCKY MOUNTAIN

Further Developments in Proven Fields Expected

DENVER.—The increase in the price of crude oil resulted in considerable optimism among producers in the Rocky Mountain area and is expected to have a stimulating effect on drilling operations this summer. While it will have some influence on wildcatting, the most pronounced reaction will be the development of more production in the proven fields, especially the smaller outlying pools. In some districts there is a larger demand than the producers can supply, credited in part to the lack of sufficient pipe lines. Extensive plans have been made for pipe-line construction in Colorado and Wyoming, but these have been delayed by inability to get prompt deliveries on pipe. Demand is increasing where companies are enlarging their refineries and soon will be in a position to take more crude, notably at Denver and Casper.

Bowdoin exploration.—The first of a series of exploratory wells on the enormous Bowdoin structure in northern Montana in Texas Co. 1-822 Bowdoin Unit, C SW SW 8-32n-32e, Phillips County, was abandoned at 5,852 ft., total depth, after testing all horizons down to and including the Cambrian. Principle tops were Madison 3,201, Devonian 4,000, Ordovician 5,455, Cambrian 5,650 ft. Elevation 2,210 ft. No important shows encountered, and most of the sands carried water. The structure, probably the largest in the Rocky Mountain area with 150,000 acres in the operating unit, produces gas from the Bowdoin and Phillips sands at 700 to 1,000 ft., and had 246 producing wells on January 1. Owing to the size of the structure and the lack of subsurface geology on well logs, one test was not expected to be conclusive, and others were provided for in the original plans. The next well probably will be located several miles to the northwest on a pronounced nose extending out from structure which will be known as the Whitewater Prospect. Unitization of between 40,000 and 50,000 acres is in process, and is expected to be completed within a few weeks. In the event of a delay, the second well will be drilled on Bowdoin. Texas Co. has approximately 150,000 acres in the area exclusive of the Bowdoin Unit, and several major companies have spreads on the northwest flanks. The Whitewater Prospect unit adjoins the Bowdoin unit.

Powder River Basin test.—A 13,000-ft. test in virgin territory out in the Powder River Basin is scheduled for this year on the Adon structure near the center of the north half of Campbell County. It will be a Texas Co. operation under a unit agreement covering 39,430 acres which has been approved as to area, formations to be tested, and drilling depth. The initial well probably will be in 35-53n-72w, 18 miles north of Gillette, and will be started as soon as final details of unit agreement are completed and approved. Powder River, a basin between the Black Hills uplift on the east and the Big Horn mountains on the west, long has been considered potential oil territory, but the depth to be drilled and meager surface geology has restrained wildcatting. Recent discoveries out in the Big Horn, Green River, and other large basins in the Rocky Mountain area, and progress in geophysics and deep drilling, has renewed interest in the Powder River Basin. In addition to Texas Co., Barnsdall, Pacific Western, Gulf, Stanolind, and other large companies have blocks of leases, the principal district being north and south of Gillette. The Adon structure has a north-south trend, is approximately 18 miles long and rather narrow. The Powder River Basin in Wyoming is approximately 150 miles long and 100 miles wide, but extends a considerable distance into southeastern Montana. Like Big Horn basin, it has numerous structures around the rim. Included in producing fields are Salt Creek, Big Muddy, Lance Creek, Osage, and a number of smaller pools.

Gebo extended.—Gebo field, a discovery in the Embar by Continental Oil Co. in 1943, was extended ¼ mile north in same company's 17 Gebo, SW SW SW 14-44n-95w. It topped the Embar at 4,920 ft. and was completed at 5,000 ft. for a potential of 325 bbl. per day on swabbing test. It ran 211 ft. lower than No. 8 on the south and approximately 440 ft. lower than the discovery. It is located five-eighths of a mile northwest of the most southeasterly well.

South Piney test.—California Co. has made a tentative location for 1 Tierney, C NE NE 15-29n-115w, an 8,000-ft. test to the Frontier, on Snider Basin (South Piney), Sublette County, western Wyoming. A block of 40,000 acres is in process of unitization, with Carter Oil Co. and British-American Oil Producing Co. controlling some acreage within the unit. Location is 10 miles northwest of the La Barge field, which produces from Wasatch sands at shallow depths. No deep test has been drilled in the immediate vicinity.

Wildcats.—Brinkerhoff-Sohio 1 Tribal 9-3n-1w, a mile extension to the southeast on Steamboat Butte, Fremont County, Wyoming, which cored good saturation in the Frontier and Dakota, topped the Embar at 6,400 ft. Drill-stem test at 6,00-16 ft. had a recovery of 190 ft. of oil and gas-cut mud, no water. General Petroleum 88-24-G, South Fork, Washakie County, Wyoming, topped the Tensleep at 10,065 ft. and Amsden at 10,480 ft., finding both hard, tight, and dry, and drilled to 10,900 ft. It has plugged back to 10,190 ft. to perforate and test the Embar. Ohio Oil Co. 2 OPC-2, Hidden Dome, Washakie County, a dis-

covery in the Embar and Tensleep, is still testing. At 4,725 ft. it swabbed 65 bbl. of 21 gravity oil in 15 hours. Texas Co. Devonian test, Keith block, Liberty County, Montana, drilled to 5,015 ft., and is plugging back to test gas in basal Ellis, with 7-in. at 2,799 ft. Last information top reported was the Jefferson at 3,955 ft.

North Douglas Creek.—Texas Co. has scheduled a 7,400-ft. test to the Weber sand on North Douglas Creek structure, Rio Blanco County, Colorado, as soon as unit agreement is approved. Northern line of the unit area, comprising approximately 54,000 acres, lies within 5 miles of the southern limits of the Rangely field. It adjoins Douglas Creek on the northwest.

New operations.—Ten new operations were reported, of which three were in Rangely field in Colorado, one in Spence field and two wildcats in Wyoming, two in Cut Bank and one in Cedar Creek, and one wildcat in Montana. One of the Wyoming wildcats is Wisenant & Trenchard 1 Martin, NE NE NW 34-45n-63w, Mush Creek district, Weston County, located 2¼ miles due north of Mush Creek Production Co. 1 Roberts, which recently was completed for 300 bbl. per day. Morton Drilling Co. has the contract. Phillips Petroleum Co. has acquired 320 acres in Section 33 on the west of this location and also tracts in Sections 4, 5, 6, and 7-44-63, a total of 954 acres. The other Wyoming wildcat is California Co. tentative lcation on the Snider Basin structure in Sublette County in 1 Tierney, C NE NE 15-29n-115w. The Montana wildcat is Ideal Oil & Gas Co. 1 Government, SE SE SW 12-22n-16e, Claggett District, Fergus County.

Completions.—Fourteen wells were completed, of which six were oil wells with initial production of 1,221 bbl., two were gas wells, and six were dry holes. Five completions, listed below, were wildcats. The development wells included three in Rangely, in Colorado, one each in East Lance Creek, Little Buffalo Basin, and Frannie, in Wyoming, and one each in Pondera, Bowdoin, and Cedar Creek, in Montana. One of the Rangely completions was a dry hole, marking the limits of the field on the west. This was Continental Oil Co. 4 Dorothy Rooth, C NW NW 22-2n-103w, which was abandoned at 7,256 ft. after finding water in the Weber, topped at 6,915 ft. Another development well abandoned was Continental Oil Co. 2-B Leach, SW SW SE 20-36n-64w, East Lance Creek, which had water in all three benches of the Dakota, and in the Lakota. This well was located midway between the two best wells in the field, 1-B Leach, on the north, up against the Foxhills sandstone, made 432 bbl. initial, and Chalmette Corp. 1 Government, on the south, higher on structure, which flowed 25 bbl. at the start, but later did much better.

COLORADO WILDCAT FAILURE

Twin Buttes, Prowers County: Ohio Oil Co. 1 Eldridge, NW NW SW 25-27s-46w, TD 6,475 ft., plugged and abd. Top Pennsylvanian 2,475 ft., Mississippian 5,180 ft., Arbuckle 5,940 ft., granite 6,472 ft.

WYOMING SUCCESSFUL WILDCAT

Herrick, Albany County: Superior Oil Co. 1 Herrick, SW NW SE 1-16n-76w, TD 3,678 ft., completed in Tensleep, pumped 315 bbl. 23°-gravity crude in 24 hours, top of Tensleep 3,632 ft., top of Frontier 1,30 ft., Dakota 2,002 ft., Casper 3,498 ft.

MONTANA WILDCAT FAILURES

Bowdoin, Phillips County: Texas Co. 1-822 Bowdoin Unit, C SW SW 8-32n-32e, TD 5,852 ft., plugged and abd. Top Madison 3,201 ft., Devonian 4,000 ft., Ordovician 5,455 ft., Cambrian 5,650 ft.

Dunkirk, Toole County: W. A. Noon 1 Sheets, NE NW SE 9-31n-1e, TD 1,850 ft., sulfur water in Ellis-Madison at 1,840 ft., plugged and abd.

Arrow Creek, Fergus County: Joe Murphy 1 Government, SE SE SE 34-20n-13e, TD 1,994 ft., Kootenai 1,370 ft., upper Ellis 1,983 ft., dry and abd.

CANADIAN FIELDS

Foremost Gas Field Gets 16,000,000-Cu. Ft. Well

CHATHAM.—In Foremost field, southern Alberta, McColl-Union 6-D, LSD 6, 25-4-10w4, finished at 2,244 ft., has initial open flow of 16,800,000 cu. ft. McColl-Union 10-B, LSD 10, 22-7-9w4, some miles to the south and west, was abandoned at 3,295 ft. McColl-Union 10-D, LSD 10, 9-4-9w4, bottoming at 2,237 ft., is bailing. McColl-Union 6-4-5-10, LSD 6, 4-5-10w4, is drilling.

Leduc.—Southwest of Edmonton, Imperial-Leduc 1 discovery well, LSD 5, 22-50-26w4, bottoming at 5,066 ft., is flowing slightly less than 250 bbl. with ¼-in. choke. Flush production on February 13, when the well came in, was 788 bbl. in 24 hours. The well got a highly porous Devonian limestone at 5,029 ft. and ran drill-stem tests. Drilling was discontinued, still in limestone, at 5,066 ft. Imperial-Leduc 2, LSD 5, 22-50-26w4, 1¼ miles south, is below 3,663 ft. Imperial-Leduc 3, LSD 10, 26-50-26w4, 2 miles northeast, is spudding, and Imperial-Leduc 4 has location in LSD 16, 15-50-26w4, a mile southeast of discovery.

Wetaskiwin.—In the Wetaskiwin area, 35 miles south of the Leduc field, McColl-Frontenac Oil 1, LSD 4, 11-45-25w4, has been abandoned in Devonian limestone at 6,502 ft. after reaching the horizon productive in Imperial-Leduc 1 and encountering only slight oil showings. The company holds over 1,000,000 acres and is planning additional drilling.

Turner Valley.—Royalite Oil 86, LSD 12, 3-21-3w5, on the east flank of the north extension, reverted to upper Blairmore formation at 9,105 ft. after getting Madison limestone at 8,951 ft. Three other Turner Valley tests are drilling, and in the north-central area Royalite-Lowery 8 has location in LSD 9, 10-20-3w5.

Keystone Valley.—Indicating a deep test, Roxana 4-K, LSD 1, 31-26-6w5, in the Keystone Valley area of the southern foothills, is in lower Benton formation below 5,948 ft. Test offsets Roxana 3-K, discontinued at 5,560 ft. when a slipping of the formation prevented further drilling. The area is in the foothills belt north and west of the Shell drilling in the Jumping Pound district and about 35 miles north and west of the most northerly Turner Valley producer.

Lloydminster.—In the Alberta section of the Lloydminster field, Shaw Peroleums 4, LSD 15, 35-49-1w4, has finished at 1,896 ft. with 30 bbl. initial production. Dalo 1, LSD 1, 35-49-1w4, finished at 2,004 ft., oil sand 1,994 ft., testing. In the northwest extension, Dimsdale 1, LSD 2, 14-50-2w4, total depth 1,986.5 ft., Sparky oil sand 1,978 ft., testing.

On the Saskatchewan side, L. & V. 1, LSD 10, 2-49-28w3, finished at 1,902 ft., Sparky oil sand 1,881 ft., testing. Hilldron 1, LSD 13, 35-48-28w3, total depth 1,892 ft., Sparky oil sand 1,883 ft., testing. Hillron 2, LSD 12, 45-48-28w3, total depth 1,920 ft., Sparky sand 1,899 ft., testing. Van Lloyd 3, LSD 7, 2-49-28w3, total depth 1,889 ft., Sparky oil sand 1,872 ft., testing. Withers-Groat 6, LSD 6, 11-49-28w3, total depth 1,876 ft., lower Cretaceous 1,694 ft., Sparky sand 1,862 ft., testing.

Athabaska tar sands.—Hon. J. A. Glen, minister of resources in the Dominion government, has announced that holdings of bituminous sands in Alberta have been returned to Abasand Oils, Ltd., under an agreement recently concluded. The company and its holdings were taken over and operated by the government in the effort to develop a source of additional oil supplies. Under the agreement, the company will pay the government $139,861 before November 1, 1948, for certain mining equipment and materials and a further sum of $1,913,437 for the government's interest in buildings, fixed machinery, and equipment. Bituminous sand rights are to be paid by royalty of 5 cents a barrel on bitumen produced or contained in sands disposed of, the first payment to be due at the end of the first year from the date production starts. It is understood the company plans to continue exploration and development.

OHIO, KENTUCKY

Frazier Gas Field Gets a Big Well

COLUMBUS.—After drilling a number of small gas wells in the new Frazier pool in northern Brush Creek Township, a large well was brought in by the Ohio Fuel on R. R. Holskey, Section 14. Clinton sand came in at 3,818-72 ft. and the well gaged 6,580,000 cu. ft. with 1,140 psi.

In the south part of the Hemlock Grove pool, the Preston Oil 2 A. C. Williard, Section 1, Bedford Township, Meigs County, was drilled in with 213,000 cu. ft. and a good show of oil. After shot, the well flowed 45 bbl. with 263,000 cu. ft. gas in 24 hours.

The Pittsfield pool in Lorain County was extended 1/3 mile due north by the Ohio Fuel 1 M. E. Burge, Lot 117, Pittsfield Township. Clinton at 2,174-82 ft. gaged 1,870,000 cu. ft. natural. The company will drill an offset well 2,000 ft. north.

The West Salem pool was extended 1 mile west by the Ohio Fuel 1 Mary Jeffrey et al, Section 1, Congress Township, Wayne County. Clinton sand at 2,915-23 ft. had 357,000 cu. ft. natural and, after shot, gaged 744,000 cu. ft. when shut in. West and south offset locations have been approved.

Seventeen locations were reported for the week with 6 in Stark County, 5 in Muskingum County, 2 in Meigs County, and 4 scattered. Sandyville field led in completions with 6 out of 17.

WILDCAT FAILURES IN OHIO

Coshocton County, Perry Township: Pure Oil 1 C. E. Hawthorne, Sec. 3, Clinton 3,244-88 ft., TD 3,416 ft.

Muskingum County, Springfield Township: J. L. Hunt et al 1 Ralph Rehl, Sec. 3, Clinton 3,595-3,644 ft., TD 3,730 ft.

EASTERN KENTUCKY OPERATIONS

ASHLAND.—Three dry holes were noted, along with a single completion.

Kentucky-West Virginia Gas Co. completed Well No. 5672 on the Matilda Kinney land, Pike County, at a depth of 2,241 ft. for an open flow of 629,000 cu. ft. in Big Lime.

Dry holes were in Well No. 5676, David Newsom property, Pike County; No. 5689, Jack Osborne, Knott County, and Nos. 2,977 and 5,694, Harrison Hall, Knott County.

New locations were on the Grover Runyon land, Pike; Robert Williams, Pike; Grant Green, Magoffin; Maltida Clark, Pike; William Hyden, Johnson; Harrison Hall, Knott, and Joseph Stewart, Knott.

WESTERN KENTUCKY

OWENSBORO.—Pure Oil Co. and Stanolind Oil & Gas Co. 1 Hamons, 2-H-67, Clay County, which had a promising show of oil in the Knox dolomite at 3,537-40 ft., is drilling below 3,785 ft., after a 4-hour pumping test, averaged 18 gal. of oil and 7 gal. of water per hour after the head was pumped off.

R. T. Holtzclaw et al 1 Cavender, 9-M-29, a McLean County wildcat, drilled to 1,161 ft., was shot in the Pennsylvanian sand

at 1,147-61 ft. with 30 qt. and will be put on pump to test.

INDIANA

EVANSVILLE.—John Savage 1 Hall, SE SE SE 19-1s-11w, a wildcat in Gibson County, is cleaning out after a 40-qt. shot in the Cypress at 1,665-75 ft. McClosky, which has not been tested, was logged at 1,911-15 ft., total depth being 1,919 ft. The same operator's 2 Hall, NE SE SE 19-1s-11w, the north offset to 1 Hall, recovered 3 ft. of saturated sand in the Cypress from core taken at 1,737-41 ft. A drill-stem test recovered 30 ft. of oil, and 250 ft. of oil-cut mud.

INDIANA WILDCAT FAILURE

Posey County: Vic-Van 1 Carr, NE SW SW 29-4s-13w, dry, TD 2,240 ft., upper Kincaid 1,578 ft., lower Kincaid 1,780 ft., Clore 1,879 ft., and Tar Springs 2,212 ft.

KANSAS

So. Central Rush County Test Looks Promising

J. M. HUBER CORP & EARL WAKEFIELD 1 Ficken, NW NW NE 32-19s-18w, Rush County, total depth 4,080 ft., is setting pipe 2 ft. in the Arbuckle, topped at 4,055 ft., to test oil show. A drill-stem test at 4,057-70 ft. recovered 20 ft. of oil and gas-cut mud in 30 minutes. The test is 13 miles west of the West Ryan pool on the southern boundary of Rush County.

The number of maximum well completions in the recently discovered Southeast Barry pool in south-central Rooks County and in the new Northwest Burnett pool on the Rooks-Ellis county line is noteworthy. The former pool's discovery well had a depthograph potential of 2,735 bbl. While the east offset was dry, four wells to the north, northwest and northeast have been completed as maximum wells in the Arbuckle lime.

The Northwest Burnett pool discovery in January 1947, was a maximum well. The east and southeast diagonal offsets, and the well over ¼ mile northeast in Rooks County have all been completed as maximum Arbuckle wells. Meanwhile, Sunray 1B Wilson, SE SE SW 35-10s-18w, is awaiting potential after swabbing 153 bbl. of oil in 2 hours, 1,000 ft. off bottom.

Falcon-Seaboard 1 Skaggs, SE NW 12-33s-2w, Sumner County, which flowed 70 bbl. and 66 bbl. per hour on two separate 3-hour flowing tests, is structurally the highest well on the Simpson sand in the Perth pool, opened in 1945, and may extend it importantly in either a west or southwest direction. This is the fourth Simpson producer in the pool, the other three being small wells, 30 bbl., 64 bbl., and 157 bbl. of oil per day.

KANSAS SUCCESSFUL WILDCAT

Rice County: Drillers Gas Co. 1 Lowery, C SE SW 36-19s-9w, gaged 7,100,000 cu. ft. gas; Wreford 1,550 ft., Americus 1,900 ft., Tarkio 2,107 ft., TD 2,300 ft.

KANSAS WILDCAT FAILURES

Barber County: J. M. Huber et al 1 Cook, W/2 SW NW 8-34s-12w, dry, TD 5,459 ft., Ft. Riley 2,070 ft., Wreford 2,290 ft., Basal Oread 3,858 ft., Lansing-Kansas City 3,974 ft., Mississippian 4,670 ft., Misener 5,114 ft., Base Mississippian 5,002 ft., chat 5,076 ft., Viola 5,115 ft., Simpson sand 5,216 ft., Arbuckle 5,417 ft.

Barton County: Stickle Drilling et al 1 Morrison, NW NW NW 29-16s-15w, dry, TD 3,653 ft., anhydrite 1,070 ft., Topeka 2,953 ft., Heebner 3,234 ft., Dodge 3,252 ft., Lansing-Kansas City 3,291 ft., conglomerate 3,560 ft., Arbuckle 3,613 ft.

Ellis County: M. J. Sullivan 1 Reemsnyder, C SE SE 33-12s-18w, dry, TD 3,760 ft., anhydrite 1,400 ft., Lansing 3,429 ft., Basal Kansas City 3,690 ft., Arbuckle 3,737 ft.

Pottawatomie County: Dalton Wood 1 Meehan, NW NW SW 25-6s-9e, dry, TD 1,753 ft., Viola 1,532 ft., granite 1,753 ft.

Rooks County: B. R. Drilling Co. 1 Roy, SW SW NE 14-8s-20w, dry, TD 3,495 ft., Topeka 2,936 ft., Heebner 3,154 ft., Lansing-Kansas City 3,174 ft., Arbuckle 3,462 ft.

MISSOURI WILDCAT FAILURE

Caldwell County: J. N. William et al 1 J. B. Russell Est., NW NW NW 20-57n-29w, dry, TD 250 ft., no tops reported.

MISSISSIPPI

Amite County Test Flows Water, Dies

JACKSON.—Gulf Refining Co. 1 Rowland, Amite County test, had total depth at 11,567 ft. With packer set at 11,432 ft., and using 3,500 ft. of water cushion, it flowed a small amount of water cushion—on drill-stem test—then died. New perforations at 11,349-53 ft.—with the packer set at 11,310 ft.—did not produce a blow. In Jones County, Gulf 1 Major was waiting on cement after setting 9⅝-in. casing at 9,020 ft., total depth.

Although Mississippi exploration work has shown some decrease since the first of the year, development work has progressed steadily. In the Brookhaven and Mallalieu fields, Lincoln County, there were 35 rigs and drilling operations in the former, while the latter field had 10 active wells.

GEORGIA WILDCAT FAILURE

Clinch County: Sun Oil Co. 1 W. J. Barlow, SW NE SW Lot 373, 12th Land District, dry, TD 3,847 ft. in quartzite.

LA.-ARK.

Blowout Threatened At Bryceland Test

SHREVEPORT.—Lion Chemical Corp. 1 Ozley, 13-17n-6w, northeast of Bryceland, was reported trying to blow out and operators were using 30 sacks of mud per hour to keep the well under control. Total depth is 10,732 ft. in shale, thought to be the Travis Peak. The Cotton Valley zone has not been called. Operators were to run 7-in. casing to 8,100 ft. as a protection string.

In Sabine Parish, 6 miles southeast of the Pleasant Hill field, R. W. Norton, Jr., et al 1 D. C. Etheridge recovered 150 ft. of oil-cut mud in a 15-minute drill-stem test at 3,426-85 ft. There was a slight blow when the tool was opened but no pressure. Operators were drilling ahead below 4,235 ft. in the upper Glen Rose. In Bossier Parish, Barnsdall Oil Co. et al 1 D. Johnson, NE SW SE 30-23n-12w, had total depth at 7,510 ft. in Travis Peak. Cores at 7,370-7,505 ft. recovered tight, red, and gray sand and shale with no shows.

In Miller County, Arkansas, E. A. Gabriel et al 1 Martindale, NW NW 32-14s-28w, was drilling below 4,710 ft. in shale and limestone. Cores at 3,700-20 ft. recovered 12 ft. of hard, sandy limestone with no shows. Tops, by samples, were: Nacatoch 480 ft., Tokio 1,610 ft., Paluxy 2,395 ft., Upper Glen Rose 3,135 ft., and base of the massive anhydrite 3,590-95 ft.

NORTH LOUISIANA WILDCAT FAILURE

De Soto Parish: Rogers Lacy 1 Pace, SE NW 28-13n-16w, dry, TD 6,648 ft., no tops reported.

OKLAHOMA

Katie-Antioch Pools May Connect Up

ANDERSON-PRICHARD OIL CORP. and Stephens Petroleum Co. 1 Seaton, SE SE NW 14-2n-2w, Garvin County, on a drill-stem test in Pennsylvanian sand at 6,418-48 ft. started flowing at an estimated rate of 50 to 100 bbl. of 42° gravity oil per hour. Casing is now being run. The test, which lies about mid-way between the Southwest Antioch field 3½ miles to the northwest and the Katie pool 4½ miles to the southeast, suggests the possibility of production's being continuous between the Katie and the Southwest Antioch fields.

Carter Oil Co. 1 Emberlin, SE SE 31-2n-1w, northwest diagonal off-set to the Katie discovery well is preparing to run drill-stem test at 6,122 ft. in the same horizon as the discovery well. Carter 1 Christian, SW SW 32-2n-1w, Garvin County, north off-set to the discovery, had show of oil at 5,160 ft. and is preparing to run drill-stem test between 5,160 and 5,200 ft. This is about 1,000 ft. above the present producing zones in the Katie pool.

Pray and Bauman 1 Myers, NW NW 7-4n-3w is drilling at 9,899 ft., 70 ft. in first Bromide sand and has cut 40 ft. of stained sand. Same operators' 1 Hinkle NW SW 6-4n-3w had saturation in both Bois d'Arc and Chimneyhill, is now drilling in Sylvan below 9,016 ft. Their 1 Frankenberg, NW NE 7-4n-3w, had saturation in Chimneyhill, is now drilling in Sylvan below 8,803 ft.

Deering Inc. 1 Howard, NW NW NE 15-5n-2w, on drill-stem test at 7,061-75 ft. recovered 240 ft. of oil cut mud with free 40° gravity oil on top, is now drilling below 7,175 ft. Misener, topped at 7,148 ft. and Hunton at 7,152 ft., both showed oil staining in cuttings.

OKLAHOMA SUCCESSFUL WILDCAT

Oklahoma County: Gulf Oil Corp. 1 Pauline, NE NE SW 23-14n-2w, gaged 1,520,000 cu. ft. gas from Bartlesville at 5,638-43 ft.; Oswego 5,354 ft., Woodford 5,711 ft., Hunton 5,760 ft., Sylvan 5,841 ft., Viola 5,990 ft., Wilcox 6,073-97 ft., 2nd Wilcox 6,165 ft., TD 6,199 ft.

OKLAHOMA WILDCAT FAILURES

Beaver County: Gulf Oil Corp. 1 Stickler, SE SE NW 5-3n-21ecm, dry, TD 3,000 ft., no tops reported.

Comanche County: Albert Beck 1 Cramer, NE NE NE 10-1n-12w, dry, TD 840 ft., no tops reported.

G. C. English 1 Coldren, SW NW NW 15-1s-13w, dry, TD 3,120 ft., Canyon 2,519 ft., Granite Wash 2,620 ft.

Cotton County: Harry Kahn et al 1 Rhodes, SW SW SW 28-1s-9w, dry, TD 2,507 ft., sand 2,221-34 ft. with a show of oil, limy sand 2,343-48 ft.

R. G. Anderson 1 Stoner, NW NE SE 13-2s-13w, dry, TD 1,297 ft., sand 1,140-56 ft.

Bridwell Oil 1 Brown, C S/2 SW SE 21-3s-11w, dry, TD 1,625 ft., sand 1,552-58 ft. with a show of oil.

Houston Browers 1 C. L. Wolf, SE SE SW 21-3s-11w, dry, TD 1,602 ft., sand 1,445-79 ft. with a show of oil and 1,565-74 ft.

Goza & Webb 1 Wilson, NE NE SW 8-4s-11w, dry, TD 1,660 ft., no tops reported.

Griffen & Barbre 1 Warren, SE SE SW 28-4s-11w, dry, TD 2,009 ft., sand 1,200-05 ft. with a show of gas.

E. P. Griffen 1 Gibson, NE SE SE 29-4s-10w, dry, TD 1,810 ft., no tops reported.

Garvin County: M. B. Armer 1 Bolling,

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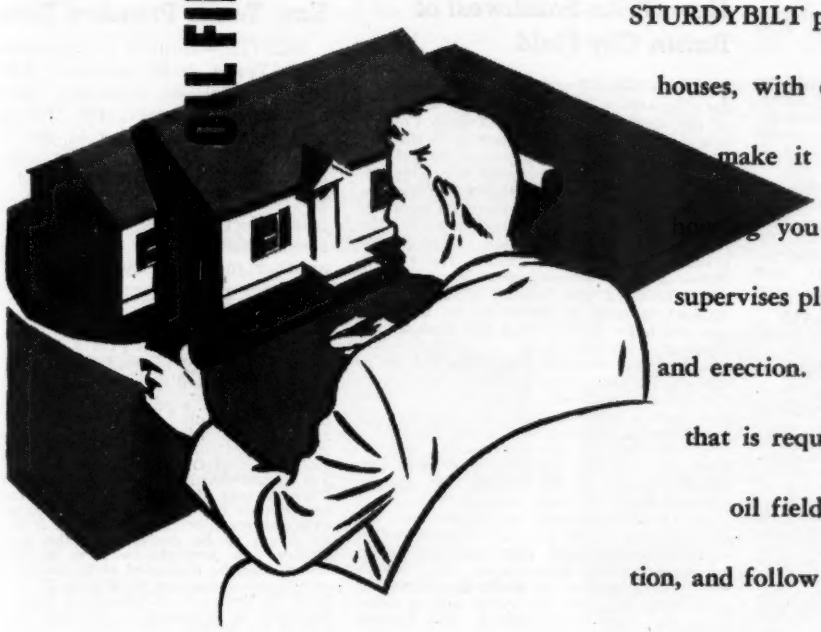

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SE NE NW 27-1n-1w, dry, TD 3,020 ft., no tops reported.

Noble County: J. E. Trigg & J. R. Porter 1 Shaw, SW SW NW 19-20n-1w, dry, TD 5,371 ft., lime 2,090-60 ft., Perry gas sand 2,225-60 ft., Layton 3,880-3,920 ft., Oswego 4,510 ft., Mississippian 4,272 ft., Woodford 5,149 ft., Sylvan 5,201 ft., Viola 5,233 ft., dense 5,282 ft., dolomite 5,295 ft., Wilcox 5,325 ft., green shale 5,355 ft.

ILLINOIS

Wayne County Test Hits in McClosky Deep Zone

MATTOON.—J. W. Rudy 1 Hampton, SW NE NW 26-1s-5e, Wayne County, which was drilled to 3,178 ft., pumped 160 bbl. of oil and 40 bbl. of water the first 24 hours and 134 bbl. of oil and 20 bbl. of water the second 24 hours from a pay zone in the McClosky at 3,154-62 ft. Casing was set at 3,153 ft. The top of the McClosky was acidized with 1,000 gal. at 3,101-03 ft. and tested dry. The deeper pay zone has not been acidized. The well is located 1½ miles northeast of the Keenville pool.

Wallace H. Wright 1 Walters, NE SW SE 19-7n-12w, in Crawford County, drilled to 1,821 ft. had Salem at 1,819 ft. After 500-gal. acid treatment, the well swabbed 2½ bbl. of oil per hour and is now being put on the pump to test.

S. Vanetis 1 Mahrenholz NW SW SE 19-3n-10w, Lawrence County, drilled to 1,904 ft., is a 190 bbl. pumper in the McClosky lime. Casing was set at 1,900 ft. and well was plugged back to 1,890 ft. Rosiclare was logged at 1,854 ft. and McClosky at 1,882-87 ft.

ILLINOIS SUCCESSFUL WILDCATS

Lawrence County: S. Vanetis 1 Mahrenholz, NW SW SE 19-3n-10w, TD 1,904 ft., PB 1,890 ft., pumped 190 bbl. oil from McClosky. Rosiclare 1,854 ft., McClosky 1,882-87 ft.

ILLINOIS WILDCAT FAILURES

Clay County: A. J. Hammer 1 Bothwell, SE SW NW 22-3n-6e, dry, TD 3,162 ft., Glen Dean 2,482 ft., Aux Vases 2,926 ft., Ste. Genevieve 2,974 ft., and St. Louis 3,145 ft.

Lawrence County: Paul Grathling 1 French, SW SE SW 35-3n-13w, dry, TD 2,479 ft., Tar Springs 1,830 ft., Cypress 2,172 ft., Ste. Genevieve 2,397 ft., and McClosky 2,434 ft.

Richland County: Pure 1 Stephens, NW NW NW 33-5s-9e, dry, TD 3,236 ft., Glen Dean 2,555 ft., Ste. Genevieve 3,136 ft., and McClosky 3,220 ft.

Shelby County: O. A. Ried 1 Drain, SE SE SE 16-10n-1e, dry, TD 1,765 ft., 7-in. 1,673 ft., Benoist 1,500 ft., Renault 1,640 ft., and Ste. Genevieve 1,685 ft.

LEGAL

U. S. DEPARTMENT OF THE INTERIOR, Bureau of Land Management, Washington 25, D. C. Notice is hereby given that sealed bids will be received until 1 P.M., Wednesday April 2, 1947, for SW¼SW¼ sec. 22, T. 11 N., R. 20 W., S.B.M., 80 acres, situated within the known geologic structure of the Wheeler Ridge field, California. This land is offered to qualified bidders of the highest cash amount per acre as a bonus for the privilege of leasing the land under section 17 of the leasing act of February 25, 1920 (41 Stat. 437), 30 U.S.C. sec. 181) as amended. Royalties payable to the United States will be at the rate of 12½ per cent to 25 per cent for oil, and 12½ per cent to 16 2/3 per cent for gas, in accordance with Schedule B in the lease form. Each bidder must submit with the bid one-fifth of the amount bid in cash, or by certified check on a solvent bank, or by money order, made payable to the order of the Treasurer of the United States, and file the showing of qualifications to receive a lease, required under 43 CFR 192.42(b) and (c). The envelopes should be plainly marked, "Bid for lease, Wheeler Ridge field, California. Not to be opened before 1 P.M., April 2, 1947." No bids received after the hour fixed herein for submitting bids will be considered. The remainder of the bonus and the annual rental at the rate of $1 per acre must be paid and a corporate surety bond in the sum of at least double the amount of rental, but in no case less than $1000 nor more than $5000 must be furnished by a successful bidder prior to the issuance of a lease. The deposits of the other bidders will be returned upon acceptance of the successful bids. The successful bidder will be required to agree not to discriminate against any employee or applicant for employment because of race, creed, color, or national origin, and to require an identical provision to be included in all subcontracts. Bidders are warned against violation of section 59, U. S. Criminal Code, approved March 4, 1909, prohibiting unlawful combination or intimidation of bidders. The right is reserved to reject any and all bids. Fred W. Johnson, Director.

CALIFORNIA

New Strike Southwest of Raisin City Field

LOS ANGELES.—Superior Oil Co.'s 55 Hackala in 32-15s-17e, 4 miles southwest of the Raisin City field in Fresno County, is a new discovery. On a test of perforated interval 7,020-34 ft., the well flowed 120 bbl. of 28.4° gravity clean oil. Superior had drilled three dry holes before making its discovery. This is the sixth of a cluster of fields discovered in this part of the county since 1941, Raisin City, Helm, Riverdale, Burrell, and Lanare. These fields follow a southeast-northwest trend. If this holds true of the present discovery the productive area is likely to be small as two dry holes were drilled less than a mile away in both directions.

A new pay discovery was chalked up in the McDonald Anticline field of Kern County when Honolulu-Wilshire 1 Layman, an easterly outpost test was brought on production at 1,175-1,210 ft. from the button bed horizon, an upper member in the Temblor in Kern County. The well was completed flowing 205 bbl. of 17.8° gravity oil through a 24/64-in. choke.

An 11,000-acre lease on property of the Kern County Land Co., a few miles south of the Wheeler Ridge field has been taken by Independent Exploration Co., which will drill a wildcat in 10-10s-20w. The big lease runs 4 miles northwest and 2 miles southeast from this location. The Grapevine-Tejon oil field is about 4 miles northeast. Bandini Petroleum Co. is jointly interested in the play.

A new fault block discovery in the Sharktooth area of the Round Mountain field in Kern County has been made by Morton and Kohlbush, 1 Alma in 15-28s-28e, which was completed on the pump for 168 bbl. of 12° gravity oil, 15 per cent cut. Water content is showing a tendency to increase. Production is coming from the Vedder formation which was topped at 2,715 ft. Total depth is 2,746 ft.

Pacific Western Oil Corp. has failed to recover drill pipe fish from its 1 National Royalties deep test in 5-26s-22e. A full string of pipe is stuck in the hole. Cuts were made at 16,315, 12,317, and 12,282 ft., but crew could not pull the fish. This well, which held the world's depth record for a time at 16,668 ft., was drilled without a fishing job until that point was reached.

In Ventura County, near the seacoast, Standard of California is preparing to abandon its deep test, 2 McGrath in 26-2n-23w near Montalvo. The well, which was drilled to 11,505 ft., has been plugged back to 8,750 ft. and before quitting the operation Standard will test showings above the plug.

Another wildcat abandonment in the Coastal District is Honolulu Oil Corp.'s 1 Signal-Bates in 36-4n-25w, 3 miles northwest of the Rincon field. Total depth is 6,381 ft.

New locations last week totaled 37 as compared to 63 the previous week. New locations this year to date, however, are running well ahead of the same period a year ago.

CALIFORNIA SUCCESSFUL WILDCATS

Kern County, Cymric area: Superior Oil Co. 1 L. & B., 20-29s-21e, flowed 312 bbl. per day, 0.1 per cent water cut, 20.3° gravity, top Carneros 2,877 ft., TD 2,925 ft.

McDonald Anticline area: Honolulu Oil Corp. 1 Honolulu-Wilshire-Layman, 18-28s-20e, flowed 205 bbl. per day through 14/64-in. choke, 1.2 per cent cut, 17.8° gravity, TD 2,213 ft.

CALIFORNIA WILDCAT FAILURES

Kern County, McKittrick area: Tide Water Associated Oil Co. 5-32 Midway-McKittrick, 32-30s-22e, dry, TD 7,230 ft.

North Belridge area: Casner and Bentz 1 Osmont, 3-27s-20e, dry, TD 2,592 ft.

East Texas Pressure Down

AUSTIN.—Bottom-hole pressure in East Texas field declined 0.73 lb. per 1,000,000 bbl. produced, based on a weighted average, for the month of February, according to the Texas Railroad Commission. The commission said water injection had been stepped up 33,352 bbl. daily but the full effect of the additional water flood will not be apparent before another month or two.

LEGAL

NOTICE TO BIDDERS FOR A SUPPLY OF NATURAL GAS

The Board of Directors for Utilities of the Department of Public Utilities of the City of Indianapolis, a municipal corporation of the State of Indiana, doing business as Citizens Gas and Coke Utility, hereinafter called the Utility, will on or before May 10, 1947, at 12 O'clock noon, Central Standard Time, receive at its office, 49 South Pennsylvania Street, Indianapolis 9, Indiana, sealed bids for furnishing a supply of natural gas for mixing purposes at a schedule of prices to be outlined in the bid. The Utility has prepared a form of contract which may be inspected at its said office at any time subsequent to March 10, 1947 and prior to the date of receipt of bids, which contract it proposes to execute with the successful bidder. The contract will run for a period of twenty years from the date of first delivery which is to be on or about July 1, 1948. The estimated requirements of the Utility are set forth in the contract.

Bidder must submit a statement of its ability to meet the requirements of the Utility as set out in the proposed contract and must likewise submit rate schedules for the gas which it proposes to sell under the terms and conditions as set out in the contract. The Utility recognizes that the ability of any bidder to deliver gas to it is dependent upon the issuance to such bidder of a certificate of public convenience and necessity by the Federal Power Commission. The Utility will undertake to support the application to the Federal Power Commission of the successful bidder for such certificate, which application the successful bidder agrees to make as soon as reasonably possible after being notified of the acceptance of his bid.

The Utility proposes to award the contract to the successful bidder on or before June 10, 1947. It reserves the right to waive any informality in any bid, to accept the proposal which in its judgment is the best bid, or to reject any or all bids.

Board of Directors for Utilities of the Department of Public Utilities of the City of Indianapolis, a Municipal Corporation of the State of Indiana, Doing Business as Citizens Gas and Coke Utility.

By THOS. L. KEMP, General Manager.

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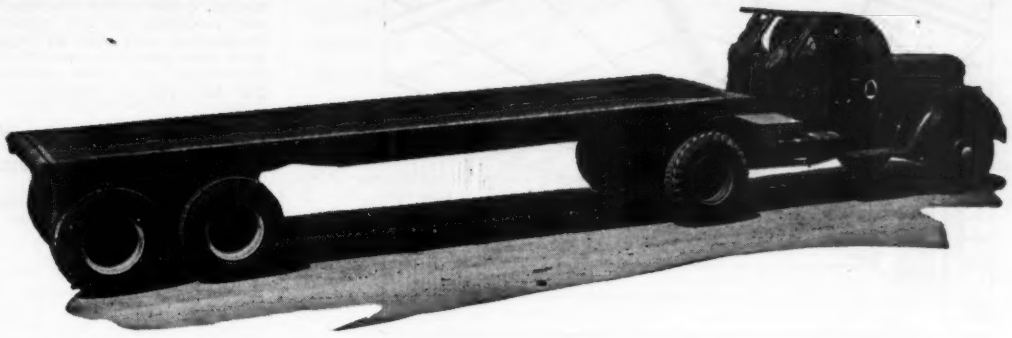

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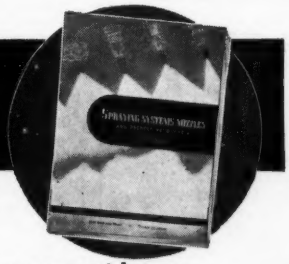

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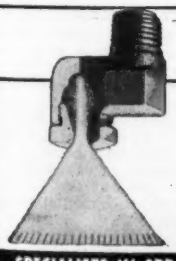

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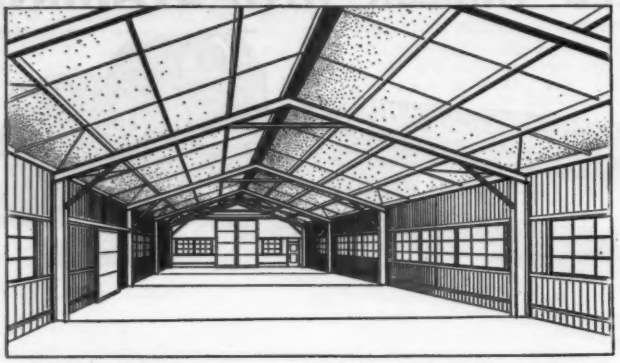

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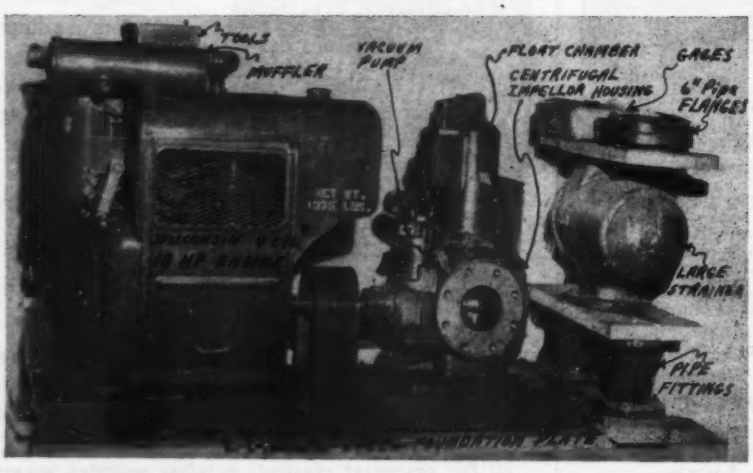

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A.I.M.E. Digests

(Continued from page 145)

ered in the field separator is sold at high gravity crude prices whereas the condensate recovered in the recovery plant is fractionated and sold as liquefied petroleum gas, gasoline, kerosene and heavier condensate at a price substantially higher than the price of crude oil.

Phase Behavior in the Methane-Ethane-n-Pentane System

G. W. BILLMAN, B. H. SAGE and W. N. LACEY, California Institute of Technology, Pasadena.

THE phase behavior of many of the binary systems containing paraffin hydrocarbon components from methane through n-pentane has been investigated during recent years. In addition the compositions of the coexisting phases in mixtures of crude oil and natural gas have been studied. However, these results do not establish the influence of the nature and amount of the other substances making up a multicomponent system upon the gas-liquid equilibrium constant of any one component. A preliminary correlation on the basis of values for binary systems was made utilizing such experimental information as was available. However, there is need for much additional information regarding behavior in systems containing more than two components.

This study indicates that at 100° F. the critical pressures of all ternary mixtures of methane, ethane, and n-pentane are lower than the critical pressure of the methane-n-pentane system at this temperature. This behavior is similar to that which has been found for other ternary mixtures of hydrocarbons so far investigated. The gas-liquid equilibrium constant of each component is markedly influenced by the nature and amount of other components present. The influence persists to pressures well below 500 psia., particularly in the case of the lighter components. This work serves further to emphasize the fact that the so-called "equilibrium constant" is a function of the state of the system rather than a function only of pressure and temperature for systems in which the components differ markedly from one another in regard to pertinent physical properties.

Because of the inherent complexity of the state of a heterogeneous multicomponent mixture, some difficulties are to be expected in obtaining general correlations of equilibrium constants for the lighter hydrocarbons in such systems. Since the chemical potential of a component in a phase is a function of the state only of that phase, rather than that of the system as a whole, its use offers somewhat better promise for purposes of generalization. However, insufficient information is as yet available to permit serious attempt to obtain accurate correlations.

Preventing Corrosion in Gas Condensate Wells

P. L. MENAUL and P. P. SPAFFORD, Stanolind Oil & Gas Co.

IN view of the great economic importance of condensate-well corrosion, an investigation as to the causative agent of this type of corrosion and the development of a method or methods of combating this problem were undertaken at the research department laboratory of Stanolind Oil & Gas Co. The cause of condensate-well corrosion had remained undiscovered and it was not until organic acids of the acetic acid series were discovered to be the causative agent, that remedial measures could be developed. The results of these early investigations were reported.

The laboratory investigation proved organic acids to be the primary factor con-

tributing to condensate well corrosion and with others correlation was found between the organic acid content of condensate water and the observed corrosion in wells. Most condensate wells subject to organic acid corrosion are situated within 100 miles of the Gulf Coast. It is a matter of interest that a relatively high content of organic acids, 432 p.p.m., was found in a corrosive distillate type of well in the Waldon field, Colorado. The corrosive agent being identified, laboratory research was undertaken to develop a remedial treatment.

Following the laboratory experiments, a field trial was started with ammonium hydroxide. Such favorable results were obtained that additional wells were placed under treatment until at present, eight of the company's formerly corrosive gas condensate wells are being treated successfully with ammonia.

It will be noted that the iron content of the produced water from the eight treated wells has been reduced substantially to zero which proves that corrosion is being effectively stopped. The quantity of ammonium hydroxide used to treat each well daily varies from 1 qt. to 1 gal.

Advantages of Brines in Secondary Recovery of Petroleum by Water Flooding

RICHARD V. HUGHES and RUDOLF J. PFISTER, Pennsylvania Grade Crude Oil Association, Bradford, Pa.

THE necessity for getting more water into sand of low permeability in any secondary-recovery water-flood operation in order to recover all the available oil always has been a major problem. In the early days of water flooding the addition of soda ash and caustic soda to fresh input waters was recommended and tried without success in the Bradford field. The most frequent difficulty was sand plugging. The use of natural and artificial brines often has been suggested for water flooding, in the belief that laboratory observations of decreasing fresh-water throughput rates in measuring water permeabilities of consolidated sand cores might be partially explained by swelling of clays.

A review of available literature bearing on the subject and related laboratory experiments are presented herein, offering an explanation for failure in use of soda ash and caustic soda waters and supporting the recent concept that every water used for input purposes in the secondary recovery of oil should possess such physical and chemical characteristics as to keep the clay content of the producing sands in a permanently flocculated condition. Produced brines meet this requirement. Their use is recommended as a means of increasing intake rates of tight sands and oil recoveries, as a solution to brine-disposal problems, and as a means of conserving a natural resource.

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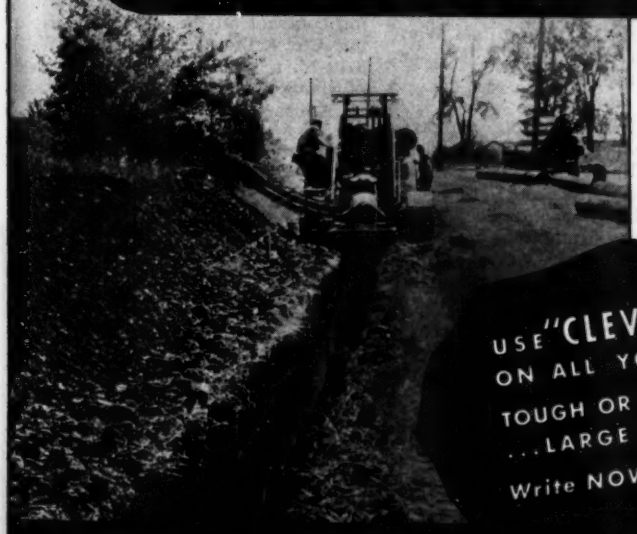

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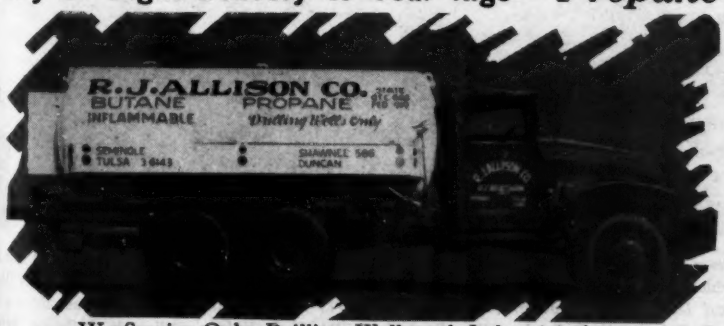

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Among the Drilling Contractors

Texola Drilling Co. will drill a wildcat in Lincoln County, Oklahoma, 6 miles north of Chandler. The test, located in NE NE NE 5-15n-4e, is the 1 Summers.

Northern Development Co., Edmonton, Alta., is finishing Lyons 3, LSD 7, 35-48-28w3 in the Saskatchewan portion of the Lloydminster field.

Meredith, Clegg & Hunt, Houston, have set 10¾-in. surface casing at 2,700 ft. on a 10,000-ft. contract for Sinclair Prairie Oil Co., on its 1 Warschak Unit in the Frelsburg area of Colorado County, Texas.

Commoil Drilling Co., Calgary, Alta., has secured contract for the drilling for Highwood-Sarcee Oils of Highwood-Lloyd 1, LSD 11, 13-48-28-w3 in the Saskatchewan section of the Lloydminster field. The well offsets D.B. 1 with 20,000,000 cu. ft gas and estimated 100 bbl. oil production.

Duncan Drilling Co., Big Spring, Tex., has filed application to drill its 1 L. M. Newton, a 3,500-ft. wildcat in northwest Howard County, Texas, about 9 miles northwest of Big Spring. The well will be dug with combination tools.

Sam L. Tennant Drilling Co., Blackwell, Okla., is moving in rotary tools 140 ft. east of the old Blankenship well for a Bartlesville test in SW 17-27n-2e, Kay County, Oklahoma, for Oklahoma Exploration Co. of Tulsa.

Zephyr Drilling Co. and W. A. Delaney, Jr., have surveyed location for a possible 6,300-ft. test 2½ miles southeast of the Katie pool in Garvin County, Oklahoma. The well, the 1 Simpson, in SW SE SE 9-1n-1w, was scheduled to get under day at once.

Bennett & Roberts have the drilling contract on the El Dorado Refining Co. 1 Stauffer, in NW NW SE 5-19-1e, a wildcat 5 miles northwest of the Lehigh pool in Marion County, Kansas. Tools were below 1,600 ft.

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HOUSTON

Crew of Coats & Hearrell Drilling Co., at the Humble Oil & Refining Co. 13 B. F. Allen, which was recently completed in Hawkins, Tex. The men are J. F. Walker; W. W. Tillery; Earl Lake; Clyde Medlin; J. M. Thomas; G. F. Hughes; Roy Lockett; Hiram McKnight; T. C. Roberts; H. C. Dunbar; Otto Denisch, driller; H. R. Holder, driller; H. J. Davis, driller; and R. E. Thacker, tool pusher

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HOUSTON TEXAS

Woods Drilling Co., Ardmore, Okla., has staked location for its 1 Duke, in SE NW NW 5-5s-1w, Carter County, Oklahoma.

Keyes Drilling Co. and Tom Allen have staked location for their 1 Chronister, in SE SE SE 35-20s-7w, Rice County, Kansas.

Commonwealth Drilling Co., Calgary, Alta., has contract for Commoil Lloyd 4, LSD 11, 10-50-1w4, recently spudded in the northwest extension of the Lloydminster field.

Aggas Drilling Co. is drilling contractor on the R. M. Shaw, A. R. Thompson, and K. W. Kilpatrick 1 Breeding, in NW SW NE 12-7n-8e, Hughes County, Oklahoma. Cellar and pits are being dug for what will be a Booch sand test. The operators have been operating for several years in Illinois with headquarters in Mattoon.

Shaw Petroleums, Lloydminster, Alta., has contract for West End 1, LSD 15, 11-50-2w3, an important outpost test in the northwest end of the Lloydminster field.

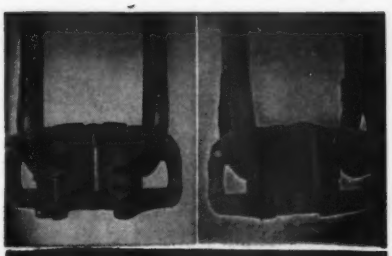
Regent Drilling Co., of Calgary, Alta., has the contract for two tests to be drilled for the G. & L. Syndicate in the Alberta end of the Lloydminster field, G. & L. 1 being in SW¼ 2-50-1w4.

Bauman Drilling Co. and R. L. Bauman, Dallas, are said to be negotiating to sell part of their interests in McClain and Garvin counties, Oklahoma, to Aurora Refining Co., Detroit. Consideration is reported to be $120,000 cash and $90,000 out of oil. One of the terms of the deal is that Aurora would acquire one-third interest in the drilling company plus the same interest in three-sixteenths of the working interest and approximately 125 acres of overriding royalty now owned by the Bauman interests.

U. S. Gasoline, Lube-Oil Tax Revenue Continues Gain

Federal internal-revenue collections from lubricating oils and gasoline during January greatly exceeded that of January a year ago while collections from the tax on oil transportation by pipe line showed a drop.

The lubricating-oil tax yielded $5,432,235.79 in taxes during January, compared with $4,187,535.72 in January a year ago; the gasoline tax yielded $34,832,332.20, against $25,495,456.59; while revenue from pipeline transportation dropped from $1,355,200.90 in January 1946 to $909,094.97 in the same month this year.



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PERSONALS

Pittsburgh Veteran Manages Three Companies

A VETERAN in the oil industry is James R. Wylie, Jr., vice president and general manager of three Pittsburgh oil and gas companies.

Wylie, whose graduation from Dartmouth College was delayed until 1919 by service in the Army Air Force during the World War 1, entered the oil business 2 years later upon receiving a master's degree from the School of Mines of the University of Pittsburgh.

From 1921 to 1925 he was engaged in the examination of oil and gas properties and oil and gas reserve studies for depletion and depreciation calculations.

Since 1926 he has been a partner in the firm of Huntley & Huntley, petroleum geologists and engineers, in the examination and appraisal of oil and gas properties for revaluation, purchase, sale, tax, and other purposes in the United States, Mexico, Canada, and Newfoundland.

For 4 years during World War 2 he was director of production in District 1 for the Petroleum Administration for War.

Since July 1946 he has been vice president and general manager of Benedum-Trees Oil Co., Hiawatha Oil & Gas Co., and Penn-Ohio Gas Co., all in Pittsburgh.

M. R. MacArthur, Phillips Petroleum Co., has been elected president of the Denver Petroleum Engineers Club. Other new officers are **K. B. Lindsey,** The Texas Co., first vice president; **C. L. Bainter,** National Supply Co., second vice president; and **T. E. Power,** Eastman Oil Well Survey Co., secretary-treasurer.

F. D. Thomas, a member of the comptroller's staff of General Petroleum Corp., has been named assistant to the comptroller of the Socony-Vacuum Oil Co. of Venezuela at Caracas.

H. Smith Clark, chief geologist, southern division, Sinclair Prairie Oil Co. at Fort Worth for the past 20 years, has resigned and will open a consulting office in Fort Worth.

Ed Downing, assistant division superintendent of the Gulf Coast division for Magnolia Petroleum Co., has been transferred to Dallas as assistant general production superintendent. In other moves, **F. R. Corbell,** Alice district superintendent, has been transferred to Houston as assistant division superintendent, and **C. E. Taylor,** Brownfield district superintendent, has replaced F. R. Corbell in the Alice district.

S. F. Shaw, San Antonio, Tex., gas-lift engineer, recently was guest speaker before the Petroleum Engineering Club of Texas A. & M. College, an affiliated student chapter of the American Institute of Mining and Metallurgical Engineers.

Lee C. Lamar, division geologist for Carter Oil Co. at Mattoon, Ill., has been transferred to Tulsa. Other recent Carter transfers include **Robert L. Craig,** gravity-meter party chief, overseas section, to the research laboratory, Tulsa, as research engineer; **William A. Crutcher,** acting central-division chief scout, Tulsa, to division chief scout, Billings, Mont.; and **Harold S. Miller,** assistant seismograph operator, Greenville, Miss., to the geophysical shop in Tulsa.

Dale I. Watkins, supervising engineer in the local engineering department in the Bayway Refinery of Standard Oil Co. of New Jersey, has been named associate chief engineer under the company's executive-development program. **Edward J. Tierney,** assistant engineer, has been named maintenance engineer in the regional engineering department; and **J. F. O'Malley** has been named chief planner in charge of the newly organized long-range planning group of the regional engineering department.

John G. Pew, vice president in charge of production of Sun Oil Co., has been elected to the board of directors of General Crude Oil Co.

Alex Voorhies, Jr., has been named director of the Esso Laboratories in Baton Rouge, La., to succeed **Dr. Cecil L. Brown,** who resigned in February to become a member of the research and development coordination group of Standard Oil Development Co. **Dr. R. W. Richardson** has been appointed associate director and **Dr. R. W. Krebs,** assistant director of the Esso Laboratories.

G. S. MITCHELL

Guy S. Mitchell, chief chemist of Lion Oil Co., El Dorado, Ark., has been elected chairman of the Ark-La-Tex section of the American Chemical Society. He succeeds **Dr. John B. Entrikin,** head of the science department of Centenary College, Shreveport, who was named to the society's National Council. **Dave N. Barrow,** assistant superintendent of the natural-gasoline department of Arkansas Fuel Oil Co., Shreveport, was chosen vice chairman, and **A. W. Trusty,** Arkansas Fuel Co. chief chemist, secretary-treasurer. Named directors of the section are: **James R. Cox,** president of the James R. Cox Co., Shreveport; **J. B. Leftwich,** chief chemist of the Silas Mason Co., Minden, La., and **Ruth Evans,** senior chemist of Lion Oil.

Robert Williams has been appointed assistant head of the process-engineering department of the Louisiana Division of Standard Oil Co. of New Jersey. **Dana Singer** has been named head of the process-design group.

Dr. R. R. Sayers, director of the Bureau of Mines for the past 7 years, will return at the end of March to the United States Public Health Service, from which he was detailed to the Department of the Interior. He will be succeeded by **James Boyd,** dean of the Colorado School of Mines. Prior to his present service with the bureau, Dr. Sayers served from 1917 to 1933 as chief surgeon and chief of the health and safety branch of the Bureau of Mines.

John Suman, vice president and a director of Standard Oil Co. (N. J.), is now in the Middle East where he is expected to visit Iran, Iraq, Saudi Arabia, and Palestine before his return to the United States. Mrs. Suman accompanied him.

George M. McNulty is now technical coordinator for the white oil division of Bayway refinery of Standard Oil Co. of New Jersey. He succeeded **Vernon F. Beyer.**

Paul Dobbertin, shift foreman in the crude-still department of the light-oils division at the Whiting refinery of Standard Oil Co. (Ind.), has been named night superintendent of the light-oils division. He succeeds **Walter S. Parker,** who is retiring after 55 years of service at the refinery.

Frank Willibrand, division superintendent in Oklahoma City for Sohio Petroleum Co., has returned from a trip to Venezuela where he inspected drilling operations being conducted by Sohio and Barnsdall Oil Co.

Aubrey Keif, chairman of The Texas Co.'s aviation division, has been named chairman of the American Petroleum Industries Committee's aviation advisory committee. Other officers are: **L. A. Henry,** Standard Oil Co. (Ind.), vice chairman, and **A. T. Hapke,** A.P.I.C. secretary. Keif, who succeeds **E. J. Burkhardt,** Standard Oil Co. of Ohio, for many years has been active in flight research of aviation petroleum products.

William M. Kellner has been named refinery night superintendent at the Bayonne, N. J., refinery of Tide Water Associated Oil Co. He fills a vacanacy caused by the retirement of **James O'Neil.** Kellner's service at the refinery began in 1916 in the filter plant. He became an engineer in 1921 and in 1945 a shift foreman in the process department. In another change at the refinery, **Bernard E. Woods** has been promoted and transferred to the process department to serve as a shift foreman.

Charles M. Reading, former assistant engineer of construction of General Petroleum Corp., has been promoted to assistant manager of the engineering department. The promotion of **Turner C. Smith** from inspection engineer to chief structural engineer for the company also has been announced. In General Petroleum's laboratories department, **R. A. Baker** has been advanced from general superintendent of laboratories to assistant manager of laboratories; **H. A. Mason,** from superintendent of laboratories at Torrance to assistant to the manager of laboratories; **John Southard** from assistant foreman, Vernon control laboratory, to foreman; and **R. D. Fisher,** from foreman, Vernon control laboratory to superintendent of laboratories at Torrance.

H. Smith Clark, Fort Worth, chief geologist for Sinclair Prairie Oil Co.'s southern division, has resigned, effective April 1, to do consulting work. Clark has been with Sinclair Prairrie for 20 years.

Eogene L. Ames, former executive vice president of Gilcrease Oil Co., was elected president of the company at a recent meeting of the board of directors. **Thomas Gilcrease,** retiring president, was named chairman of the board. Other officers elected were: **Lester Whipple,** vice president; **Thomas Gilcrease, Jr.,** secretary; **Barton Gilcrease,** treasurer; **Miss Evelyn Britain,** assistant secretary; and **C. A. Solt,** auditor. The company, which maintains headquarters in San Antonio, operates in Texas, Oklahoma, and Kansas.

Austin P. Cupit, senior engineer, engineering, at the Wilmington, Calif., refinery of Shell Oil Co., Inc., has been made senior engineer, development, at the company's head office in San Francisco. Personnel changes in Shell's West Coast production department include: **Fred E. Hummel,** mechanical engineer, Long Beach, Los Angeles basin division, to Bakersfield in the San Joaquin division; **Elmer Price,** drilling foreman, from Ventura in the coastal division, to Bakersfield; and **Roy Robinson,** drilling foreman, Sacramento in the San Joaquin division, to Bakersfield. In Shell Chemical Corp., personnel changes include: **N. H. McKay,** technical assistant at Dominguez, to assistant department manager; **C. H. Plomteaux, Jr.,** assistant department manager at Houston, to department manager; and **V. M. Wilson,** senior technologist at Houston to assistant chief technologist.

Wayne R. Bright, junior engineer, Stanolind Oil & Gas Co., has been transferred to Brownfield, Tex.

David L. Dooley, Stanolind Oil & Gas Co., has been elected chairman of the recently organized Oklahoma City section of the American Institute of Mining and Metallurgical Engineers. Other new officers are: **Glenn Stearns,** West Edmond Engineering Association, first vice chairman; **Dan Howard,** Oklahoma Corporation Commission, second vice chairman; and **Robert J. Beams,** Shell Oil Co., Inc., secretary-treasurer. **E. C. Dahlgren,** Interstate Oil Compact Commission, and **Phillip Montgomery,** Halliburton Oil Well Cementing Co., were elected directors.

Donald C. Sandy, laboratory employe in the Pittsburgh Grease Works of Standard Oil Co. of Pennsylvania, has been transferred to the foreign refining coordination department of Standard Oil Co. (N. J.).

James W. Kisling, Jr., geologist, has opened offices in the Palace Building in Tulsa. He is associated with **W. C. Bednar,** petroleum engineer.

Orville Braden, assistant regional engineer and estimator in the Bayonne refinery of Standard Oil Co. of New Jersey, has been named regional engineer and supervisor, succeeding **Edwin Leech,** who recently retired. **Thomas J. Hofgren** has been named foreman in the carpenters department in the same plant.

Robert M. Shepardson is the new director of Standard Oil Development Co.'s process division at the Bayway refinery. **Frederick W. Schumacher** has been named associate director, and **Burton C. Belden** and **Albert B. Welty, Jr.,** have been named assistant directors. Shepardson succeeded **Amiot P. Hewlett,** who was transferred to New York as an adviser on employe matters in the company's technical operations.

New officers of the Seminole, Okla., chapter of the American Petroleum Institute are M. W. Curtis, engineer, Mid-Continent Petroleum Corp., secretary-treasurer; J. F. McDonald, district engineer, Gulf Oil Corp., second vice chairman; Clyde J. Randles, gasoline superintendent, Carter Oil Co., first vice chairman; and F. J. Willbanks, district manager, Hinderliter Tool Co., chairman

Equipment Men in the News

Core Laboratories Makes Personnel Changes

W. E. STILES

W. H. Davison, vice president and general manager, has recently announced the following changes in personnel and the redesignation of areas now being serviced in the United States by Core Laboratories, Inc., Dallas. W. E. Stiles, formerly district engineer of the North Texas district, has been transferred to Houston to serve as division manager of the newly formed Gulf Coast division covering Houston, New Orleans, Lafayette, Lake Charles, Beaumont, Corpus Christi, McAllen, Alice, and

E. A. NICHOLS

R. S. BYNUM

San Antonio. Earl A. Nichols, formerly manager of the reservoir fluid analysis department, has been advanced to division manager of the Mid-Continent division which includes North, East, and West Texas, Oklahoma, northern Louisiana, Arkansas, Mississippi, Illinois, Indiana, Michigan, and New Mexico. Rufe Bynum, formerly with the general office in Dallas, has been promoted to district engineer of the central district. The Shreveport district has been renamed Ark-La-Tex and will continue under the supervision of Ralph W. Parnell, district engineer. Nelson W. Williams has been advanced from district engineer of the California district to manager of the western division which covers all operations in the Pacific and Rocky Mountain areas. T. L. Kennerly, former assistant district engineer for the Illinois district, has been advanced to district engineer of the California district.

Industrial Engineering Forms New Division

A division of Industrial Engineering Corp. has been organized to serve foreign oil companies. W. T. Chappe, general manager of the new division, announces a complete sales engineering service for new and used equipment as well as heavy industrial construction equipment. A unique service of dismantling and erection engineering on all types of oil plants is also offered. Chappe, refinery engineer and alumnus of University of California, directed the dismantling of Richfield refinery at Hynes, Calif., in 1943 and 1944.

Rheem-Australia to Erect New Plant

Rheem-Australia Pty., Ltd., Australian affiliate of Rheem Manufacturing Co., has acquired a 15-acre site in Fremantle, largest port in western Australia, and will erect a plant to manufacture steel shipping containers, it is announced by R. S. Rheem, president of the American company. Rheem-Australia, which is jointly owned by Rheem Manufacturing Co. and Broken-Hill Pty., Ltd., is presently operating two plants in Sydney as well as plants in Melbourne and Brisbane.

B.S.&B. Makes Administrative Changes

The death of J. A. "Uncle Jake" Grubb, regional manager of the Kansas and Northwestern territories of Black, Sivalls & Bryson, Inc., Kansas City, has brought about three changes in the administrative personnel, according to A. J. Smith, president of the company. Ed Nelson, who worked with Grubb for several years, has been transferred from the propane-system sales force in Kansas City to Great Bend, Kans., where he will direct the Kansas operations. Marion Miller, who has been Grubb's assistant in the Wichita sales office, will be in charge of that office. Lee Kelton will act as district manager in charge of the Connor Tank Division in its operations in Wyoming and Colorado.

Officials Promoted in Cummins Engine

Promotions of two officials of Cummins Engine Co., Inc., Columbus, Ind., have been announced by Hugh T. Miller, chairman of the company's board of directors. The changes were effective January 1. V. E. McMullen is now executive vice president of the company, and R. E. Huthsteiner is vice president and general manager. Simultaneously announced were the appointments of Leonard W. Beck as general sales manager and Waldo M. Harrison as controller.

Republic Supply Opens Denver Sales Office

Republic Supply Co., Houston, announces the extension of its supply service to the upper Mountain States area with the opening of a sales office in Denver. The new office is located at 639 Continental Building, and Denver H. (Friday) Hyler is in charge.

General Marshall Joins Kellogg

J. C. MARSHALL

H. R. Austin, president of the M. W. Kellogg Co., Jersey City and New York, has announced that Brig. Gen. James Creel Marshall has been retained on the engineering staff of that company. Foremost among General Marshall's more recent Army activities was his service on the atom-bomb project. In June 1942, he was directed to form the organization which in August of that year became the Manhattan Engineer District, charged with the development of the atom bomb.

Spencer Chemical Adds Dinges

Harold Dinges, formerly with Mathieson Alkali Corp., has recently joined Spencer Chemical Co., Kansas City, as director of sales for the chemical division, it is announced by J. M. Stratton, advertising manager.

Hall in South America for Weatherford Spring

JESS E. HALL, SR.

Jess E. Hall, Sr., owner of Weatherford Spring Co., Weatherford, Tex., is on a 2-month tour of South American oil fields. The trip is being made at the request of some of the major oil companies. The purpose of Hall's tour is to acquaint producers in the South American countries with company tools and methods for the prevention of cementing failures in well completions. Accompanying Hall is A. J. Teplitz, engineer with Gulf Research & Development Corp. Roland Smith, export director of Weatherford Spring Co., left Houston March 8 to join Hall and Teplitz in Venezuela.

Hewitt Rubber Establishes Islands Outlet

Hewitt Rubber Division of Hewitt-Robins, Inc., has announced the appointment of Hawaiian Equipment Co., Ltd., Honolulu, as its distributor of industrial hose and belting throughout the Hawaiian Islands. The new company is directed by W. P. Sheehan, vice president and general manager.

John Elevated in Mid-Continent Supply

FRANK JOHN

Frank John has been promoted to the post of assistant to the president and director of purchases of Mid-Continent Supply Co., Fort Worth, it is announced by K. W. Davis, president. In this new position, John will continue to direct purchases for the company with the new added responsibility of directing policies for its operation.

Dowell Appoints Bowersock Sales Engineer

Dale D. Bowersock has been appointed sales engineer for Dowell Incorporated, with headquarters at Brownfield, Tex. Filling of this new post to improve coverage of the Levelland station's widespread area and to assist other stations was announced by N. D. Webb, West Texas-New Mexico district manager, with headquarters at Midland, Tex.

Porth in South America

Walter H. Porth, manager of the International division, A. O. Smith Corp., Milwaukee, is traveling through Brazil, Uruguay, and Argentina to establish postwar relations with his company's customers and distributors. This is his fourth visit to those countries since his long-term residence in the early 1930's in Buenos Aires and subsequently in Rio de Janeiro.

Luscombe Advances Norris

Eugene W. Norris, chief engineer for Luscombe Airplane Corp., Dallas, has been appointed vice president in charge of engineering, it is announced by L. H. P. Klotz, president. Norris, who is a native of Wichita, came first with Luscombe in November 1945 and was named chief engineer at that time.